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1985/86 ST. CROIX RIVER WATER QUALITY REPORT

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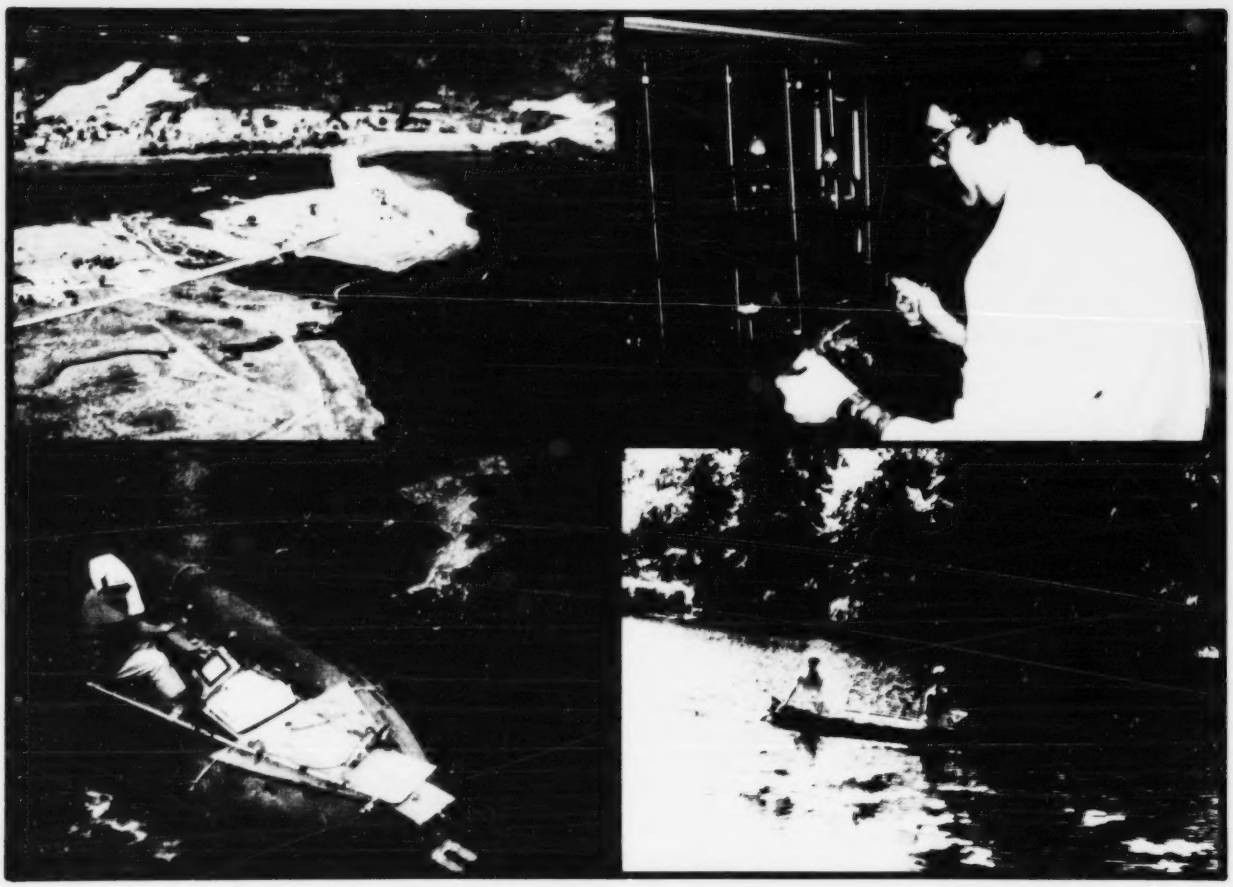

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INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER QUALITY BRANCH
MONCTON, NEW BRUNSWICK

1985/86 St. Croix River

Water Quality Report

IW/L-AR-WQB-87-119

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A copy will be made available in French upon request

Table of Contents

	Page
Abstract	ii
Résumé	iii
Introduction	1
Study Area	2
Methods	3
Results and Discussion	5
Background Water Quality	5
Woodland Station	8
Milltown Station	10
Milltown AWQM	12
References	19
List of Tables	20
List of Figures	25

Abstract

This report presents the results of the 1985-86 St. Croix River water quality monitoring program. Physical parameters, major ions, heavy metals and nutrient concentrations are presented for three stations sampled on six dates and three stations sampled on one occasion in April 1986. Hourly data from the Milltown Automatic Water Quality Monitor (AWQM) for the period February 7, 1986 to August 31, 1986 are presented in the form of box-and-whisker plots. These data are discussed briefly and a specific conductance-discharge relationship is developed using daily mean specific conductance measured by the AWQM and daily mean discharge measured by the international gauging station at Baring, Me.

Resume

Ce rapport presente les resultats issus du programme de surveillance de la qualite des eaux de la riviere Ste-Croix pour 1985-1986. Les resultats d'analyse des parametres physiques, ainsi que les concentrations mesurees d'ions majeurs, de metaux lourds et d'elements nutritifs, sont presentes pour trois stations d'echantillonnage visitees a six occasions, et pour trois autres stations d'echantillonnage visitees une seule fois en avril 1986. A toutes les heures, des donnees furent recueillies a l'aide du moniteur automatique de la qualite des eaux installe a Milltown, pour la periode s'etalant du 7 fevrier 1986 au 31 aout 1986. Ces donnees sont presentees sous forme de traces en boites. Ces donnees sont egalement discutes brievement et une relation est developpee entre la conductivite specifique et le debit. Pour ce faire, les valeurs moyennes quotidiennes de conductivite specifique, obtenues grace au moniteur automatique, ainsi que les valeurs de debit moyen quotidien meaurees a la station de jaugeage internationale situee a Baring, Me., furent utilisees.

Introduction

To assist the Advisory Board on Pollution Control in co-ordinating water quality planning and management efforts in the International St. Croix River Basin, the Water Quality Branch conducts regular water quality sampling in the international portion of the river. The collected samples are analyzed for a variety of parameters, including physical characteristics, major ions, trace metals and nutrients. Data resulting from this effort are also used in the development of water quality objectives with particular reference to the passage of Atlantic Salmon (Salmo salar), an effort in which the Water Quality Branch participates.

This report presents the water quality data from six stations sampled during the period May 1985 to April 1986.

In addition, the Water Quality Branch, in co-operation with the U.S.G.S. receives data on a real-time basis via satellite retransmission from the A.W.Q.M. at Milltown. This report also presents the A.W.Q.M. data for the period February 7, 1986 to August 31, 1986.

The Study Area

The study area is that part of the river which forms the international boundary between the United States and Canada, and extends from Forest City Stream in the river headwaters to Milltown, where the river enters the estuary, a distance of approximately 124 km. The upper 110 km of river is considered to be of pristine quality, but the 14 km stretch of river between Woodland, Me. and Milltown, N. B. has been termed a water quality limited segment, caused by a major industrial discharge from the Georgia-Pacific Kraft Pulp Mill at Woodland, Me., and to a lesser extent by municipal discharge and combined sewage outfalls in Woodland and Baileyville, Me. Although this stretch of river is still considered to be a water quality limited segment, water quality conditions here have much improved since the 1960s and 1970s, to the extent that the river is now capable of supporting an anadromous run of Atlantic Salmon (Salmo salar).

Methods

Water quality samples were collected on six occasions during the study period at three different locations in the river basin - Kellyland, Woodland and Milltown. Samples were also collected from Forest City Stream, Diggity Stream and from the St. Croix River at St. Croix, N. B. - Vanceboro, Me. on one occasion in April.

The Forest City Stream, Diggity Stream, Kellyland and St. Croix - Vanceboro stations are considered to be of pristine quality and are thus indicative of background water quality. The Woodland station is located approximately 200 m downstream of the effluent outfall from the Georgia-Pacific waste-water treatment facility, and samples collected here serve to characterize the chemical composition of the effluent after slight dilution by river water. Samples collected at the Milltown station serve to characterize the chemical quality of the river as it enters the estuary.

Sampling station location descriptions and NAQUADAT numbers are presented in Table 1. Figure 1 shows the sampling site locations in the basin.

Grab sampling was conducted as outlined in the "Sampling for Water Quality" manual (W.Q.B., 1983). A list of the water quality parameters for which the samples were analyzed, their corresponding NAQUADAT Parameter Codes, and the detection limits of the analytical methods employed are presented in Table 2. The

analytical methods employed are described in the NAQUADAT Dictionary (W.Q.B., 1986).

Daily mean discharge rates of the St. Croix River at Baring, Me., for the six sampling dates are listed in Table 3.

In compliance with Water Quality Branch Atlantic Region Quality Control/Quality Assurance protocol, roughly 15% of the grab samples were collected in triplicate, and field preservative reagent blanks were prepared for each sampling occasion when samples were preserved in the field. The results of these QC/QA procedures are presented in the appropriate tables.

Data from the U.S.G.S. A.W.Q.M. at Milltown was obtained by using a Labarge GOES satellite retransmission platform, and the data was stored on the Water Quality Branch VAX 750 minicomputer. The hourly measurements are presented in this report in the form of box-and-whisker plots, which were constructed on the VAX 750 using the RS-1 statistical software package. Dissolved oxygen percent saturation values for the hourly data were calculated using the formula

$$\text{D. O. (\% sat.)} = \frac{\text{(D. O. (mg/L))}}{(14.161 - 0.3943\ T + 0.00714\ T^2 - 0.0000646\ T^3)} \times 100$$

where T = Water temperature in °C.

Results and Discussion

Physical measurements, major ions, heavy metal and nutrient concentrations for six sampling dates at three of the sampling stations, and one sampling date at three of the other sampling locations are presented in Tables 4 to 8 respectively.

Background Water Quality - Station nos. 00NB01AR0002, 00NB01AR0011, 00NB01AR0013, 00NB01AR0029.

The sampling stations at Forest City, St. Croix - Vanceboro, Diggity Stream and Kellyland are all located upstream of Woodland and are thus representative of background water quality conditions.

The Kellyland station is 15 km upstream of Woodland (1.3 km downstream of the Grand Falls Dam), the St. Croix - Vanceboro station is approximately 63 km upstream of Woodland (at the outlet of Spednic Lake), and the Forest City station is approximately 100 km upstream of Woodland (at the outlet of Grand Lake). The Diggity Stream station is located at the outlet of First Lake, which flows out of Wauklahegan (McAdam) lake, whose drainage basin includes at least part of the village of McAdam, N. B.

Water temperatures at Kellyland ranged from 0.0 °C in March 1986 to 24.0 °C in July 1985. Dissolved oxygen concentrations were high on all sampling occasions, ranging from 7.3 mg/L (90.3% saturation) on July 25, 1985 to 14.0 mg/L (100.2% saturation) on

February 7, 1986. Water colour at this sampling station ranged from moderate (30 Hazen Units) in July 1985 to fairly high (80 Hazen Units) on November 15, 1985. Water colour of streams draining forested areas, especially deciduous forest, often exhibit seasonality with the higher values occurring in late fall when decaying leaf matter increases the allochthonous organic load of the river water.

The waters of the St. Croix River upstream of Woodland are dilute, and have pH values in the 6.5 to 7.0 range. At Kellyland, specific conductivities ranged from 32 uS/cm to 42 uS/cm, and on the one sampling occasion in April 1986, specific conductances were 30 uS/cm, 32 uS/cm and 30 uS/cm at Forest City Stream, St. Croix - Vanceboro and Diggity Stream sampling stations respectively. Sum of constituents ($Ca + Na + K + Mg + SO_4 + Cl + HCO_3$) ranged from 15.75 mg/L to 21.68 mg/L at Kellyland, and on the one sampling occasion in April 1986, sum of constituents were 14.72 mg/L, 15.15 mg/L and 14.18 mg/L at the Forest City Stream, St. Croix - Vanceboro and Diggity Stream sampling stations respectively. The dominant cation at all of the background water quality stations is calcium, ranging from 0.170 to 0.245 meq/L at Kellyland, and being 0.180 meq/L, 0.150 meq/L and 0.110 meq/L at the Forest City Stream, St. Croix - Vanceboro and Diggity Stream sampling stations respectively. At the Kellyland station, the second most abundant cation is shared by the magnesium (0.060 to 0.091 meq/L) and sodium (0.061 to 0.087 meq/L) ions, and on the one sampling occasion in April, magnesium was the second most abundant cation (0.047 meq/L)

followed closely by sodium (0.039 meq/L) at the Forest City Stream sampling station. At the St. Croix - Vanceboro and Diggity Stream sampling stations, the second most abundant cation was sodium, having 0.078 meq/L and 0.091 meq/L concentrations respectively.

At the Kellyland station, the anions are dominated by bicarbonate (0.114 to 0.162 meq/L), followed by sulphate (0.071 to 0.129 meq/L) and chloride (0.045 to 0.082 meq/L).

On the one sampling occasion in April at both the Forest City Stream and St. Croix - Vanceboro sampling stations the dominant anion was bicarbonate (0.156 meq/L and 0.088 meq/L respectively). The dominant anion at the Diggity Stream sampling station was chloride (0.099 meq/L) followed by sulphate (0.077 meq/L). The second most dominant anion at the Forest City Stream sampling station was sulphate (0.067 meq/L) followed by chloride (0.039 meq/L). The position of second most dominant anion at the St. Croix - Vanceboro sampling station was chloride (0.082 meq/L) followed by sulphate (0.077 meq/L).

Concentrations of copper, lead, mercury and cadmium were below or near the limit of detection of the analytical method used to analyze the samples at all of these background stations. Iron and manganese were in the range of < 0.05 to 0.20 mg/L and < 0.01 to 0.047 mg/L respectively. Aluminum concentrations ranged from 0.020 mg/L to 0.130 mg/L.

Nutrient concentrations at all of the background stations were low, total phosphorus ranging from 0.003 mg/L to 0.010 mg/L, total nitrogen concentrations from 0.10 to 0.22 mg/L, nitrite + nitrite concentrations from < 0.01 to 0.12 mg/L and dissolved organic carbon ranging from 6.2 to 14.0 mg/L.

Woodland Station - Station no. 00NB01AR0014

This water quality sampling station is located on the United States side of the river, approximately 200 m downstream of the Georgia-Pacific waste-water treatment plant outfall. River morphometry at this location (a small island in the river at the point of waste-water outfall) prevents lateral mixing of the effluent with river water, and hence samples collected at this sampling location provide an indication of the chemistry of the treated Kraft mill effluent. Tables 4 to 8 present the physical parameter, major ion, heavy metal and nutrient data respectively.

The temperature of the St. Croix River at Woodland is highly dependent on effluent temperatures, and as a consequence remains high throughout the year (15.0 °C in February 1986 to 32.0 °C in July 1985). Water colour here is extremely high (< 1000 Hazen Units) due to elevated concentrations of dissolved organic matter and black pulping liquor in the treated mill effluent. The pH of the treated Kraft mill effluent tends to be slightly alkaline, ranging from 7.3 to 7.7 units during the sampling period. Specific conductance at Woodland exceeds that observed at Kellyland by a

factor of 60 to 70. This is reflected in the major ion concentrations, with the sum of constituents (Ca + Na + Mg + K + Cl + SO_4 + HCO_3) being 60 to 85 times higher than at Kellyland. Unlike the water at Kellyland, major ion chemistry at this site is dominated by sodium and chloride ions, a result of their production in the Kraft pulping and bleaching process at the Woodland mill.

Mercury concentrations ranged from below to slightly above detection limit for samples collected from this location, while cadmium concentrations ranged from 0.001 to 0.009 mg/L, lead from 0.003 to 0.010 mg/L and copper from 0.002 to 0.010 mg/L. Iron concentrations were elevated (0.26 to 0.88 mg/L) while manganese concentrations were two orders of magnitude greater than those in samples from Kellyland. Extractable aluminum concentrations were very high, ranging form 1.9 to 5.0 mg/L, presumably resulting from the use of alum in process water treatment in the mill.

The organic nature of Kraft mill effluent is reflected in the elevated concentrations of nutrients. Dissolved organic carbon concentrations ranged from 70.0 to 110.0 mg/L, total nitrogen ranged from 2.80 to 3.80 mg/L and nitrite + nitrate from 1.80 to 3.50 mg/L. Total phosphorus determinations were not made on samples collected from this location because of analytical interferences.

Milltown - Station no. 00NB01AR0001

Samples collected from this location, 14 km downstream of Woodland, serve to characterize the water quality of the St. Croix River as it enters the estuary. Water temperatures measured here are $\pm$ 1 C° of water temperatures measured at the Kellyland station on the same date, the Kraft mill effluent having reached thermal equilibrium with the river water by the time it reaches this location. However, the effects of effluent loading are reflected in the elevated water colours measured at this site (ranging from 10 to 45 Hazen Units higher than water colour measured at Kellyland on the same sampling date).

Although the highly organic nature of the treated Kraft mill effluent results in some oxygen demand in the lower 14 km stretch of the river, on all occasions the 1985/86 grab sampling dissolved oxygen concentrations were above the water quality objective of 60% saturation or 5.0 mg/L. Dissolved oxygen concentrations ranged from 5.8 mg/L to 13.8 mg/L in response to varying water temperature. Dissolved oxygen saturations ranged from 73.3% to 98.0% with the lowest level corresponding to high water temperature, high water colour and high specific conductance.

The pH of river water measured at this location ranged from 6.6 to 7.0 units, and samples collected from this location had pH values ranging from 0.1 to 0.3 pH units higher than samples collected on the same date from the Kellyland station, the result

of mixing of the slightly alkaline treated pulp mill effluent with the river water.

Major ion chemistry at Milltown reflects a mixture of the background calcium bicarbonate dominated waters of the upper St. Croix River and the sodium chloride dominated pulp mill effluent. Specific conductances are highly variable, ranging from 58 uS/cm to 143 uS/cm. The dominant cation in all of the samples collected during the 1985-86 sampling period was sodium (0.270 meq/L to 0.774 meq/L) followed by calcium (0.170 to 0.349 meq/L). Chloride was the dominant anion (0.195 to 0.677 meq/L) followed closely by bicarbonate (0.160 to 0.372 meq/L). The sum of constituents (Ca + Na + Mg + K + Cl + SO_4 + HCO_3) in samples collected from this station range from approximately 2 to 5 times higher than the sum of constituents in samples collected on the same date at the Kellyland station.

Concentrations of copper, lead, cadmium and mercury were at or below detection limits on all sampling occasions at this station. Because of the high levels of aluminum, iron and manganese in the treated Kraft mill effluent, concentrations of these metals were higher at this sampling station than those measured at the background station at Kellyland. However, the dilution effect of river water on the treated Kraft mill effluent serves to lower the concentrations of manganese and aluminum measured in river water at this location by an order of magnitude or greater from the

concentrations measured in samples collected from the Woodland station.

Nutrient concentrations at this station are slightly higher than the values observed at Kellyland. Total phosphorus at this sampling station ranged from 0.016 to 0.056 mg/L, total nitrogen from 0.19 to 0.30 mg/L and nitrate + nitrite from 0.06 to 0.23 mg/L. Dissolved organic carbon at this station ranged from 6.5 to 12.0 mg/L and did not differ significantly from D.O.C. concentrations measured at the Kellyland sampling station on the same date.

Milltown AWQM Data

Appendix 1 presents the hourly Milltown AWQM data for the period February 7/86 to August 31/86. Also included are daily mean discharge hydrographs of the St. Croix River at Baring, Me. (U.S.G.S. Gauge 01021000) for the period February 7/86 to July 15/86.

It should be noted that both the monthly box-and-whisker plots of the AWQM data and the stream discharge hydrographs were constructed from provisional data which may be edited before being published. The Water Quality Branch and the U.S.G.S. are presently developing a means whereby both organizations will cooperate in validating and publishing the final AWQM data.

Due to operational problems, the AWQM did not operate during the month of January and the first week of February 1986. However, since then the AWQM has operated very well, with data capture in Moncton being in the range of 80-90% theoretical capability. Some of the AWQM data in Moncton was lost due to computer down-time at the Water Resources Branch in Ottawa, who act as an intermediary repository for the data between Moncton and the satellite ground station in Wallops Island, Virginia.

Figures 2 to 36 are box-and-whisker plots of the five parameters measured by the AWQM over the period February 7/86 to August 31/86. The box-and-whisker plots are a graphical means of displaying the minimum, 25th percentile, median, 75th percentile and maximum parameter values of the hourly measurements recorded per day. Also included on the plots is the mean daily discharge (cms) of the St. Croix River measured at the international gauging station at Baring, Me.

Water Temperature

Water temperatures were generally below 1 °C until the last week of March, when a gradual increase began and by the end of April water temperatures had reached the 12.5 to 13.0 °C level. Water temperatures during the month of May were fairly constant in the 11 to 15 °C range with increasing water temperatures towards the end of the month, presumably in response to warmer air temperatures during the latter part of May. Water temperatures in

June remained in the 15.0 to 22.0 °C range and this trend was followed until the third week of July when water temperature reached a high of 23.4 °C. During the first three weeks of August water temperatures remained in the 19.1 to 23.4 °C range, but during the last week of August, there was a cooling trend, with values as low as 14.8 °C being measured.

Dissolved Oxygen (mg/L)

During February, March and the first three weeks of April the daily median dissolved oxygen measurements were in the 13.0 mg/L to 15.0 mg/L range. Near mid-April, in response to increasing water temperatures, daily median dissolved oxygen concentrations dropped to the 10 to 12 mg/L level. This trend continued until the 20th of May, when daily median dissolved oxygen concentration dropped to slightly below the 10 mg/L level. During the first three weeks of June median concentrations remained in the 9.0 to 10.0 mg/L range, but by the last week of June, median daily dissolved oxygen concentrations were in the 7.0 to 8.0 mg/L range. This trend continued during the first three weeks of July, but during the last week of July dissolved oxygen concentrations fell to the 6.5 to 7.0 mg/L range. During the month of August, dissolved oxygen concentrations remained steady, with daily median concentrations being in the 6.8 to 7.5 mg/L range. Significantly, the lowest dissolved oxygen concentration measured during the February 7 - August 31/86 period was 6.4 mg/L (measured on July 27), well above

the 5.0 mg/L water quality objective for dissolved oxygen concentration in the St. Croix.

Dissolved Oxygen (% saturation)

Dissolved oxygen (% sat.) levels remained high, with daily median values being in the 90 to 120 % saturation range until June 25, when lower river discharge and higher water temperatures caused a lowering of dissolved oxygen levels to the 80-90% saturation range. Dissolved oxygen continued to be in the 80 to 90% saturation range until the 26th of July, when the daily median levels fell slightly to the 75-85% saturation range. Throughout the month of August dissolved oxygen remained in the 78 to 90% saturation range. Significantly, during the latter part of June when daily mean river discharge was in the 24.6 to 30.5 cms range for a one-week period, dissolved oxygen levels never fell below the 81% saturation level.

The lowest dissolved oxygen % saturation level measured during the February 7 - August 31/86 period was 74.2%, well above the 60% water quality objective for the St. Croix.

pH

The median pH of the St. Croix River at Milltown during the February 7 to August 31/86 period was 6.8. This parameter is

discharge related, although to a lesser extent than specific conductance.

In general, during periods of high river discharge, pH remains in the 6.6 to 6.8 range, not significantly different from pH values measured upstream of Woodland.

However, during periods of relatively low river discharge, such as occurred during the last week of June, pH levels tend to rise to the 6.9 - 7.2 range, probably the result of the lower dilution rate of the slightly alkaline Kraft mill effluent being discharged at Woodland.

Specific Conductance

Specific conductance measured by the AWQM at Milltown between February 7 and August 31/86 varied widely with a range of 46.9 to 167.9 uS/cm. Specific conductance is inversely related to river discharge, with increased discharge rates allowing for greater dilution of the relatively high ionic strength Kraft mill waste. Hence, the lower conductance values were measured in April and the first two weeks of May when spring run-off kept the mean daily discharge in the 100-200 CMS range. However, during the third week of May, mean daily discharge dropped to the 28 to 30 CMS range, and specific conductance measurements were elevated from the 60-80 uS/cm range to the 120-130 uS/cm range. However, by the last week of May, mean daily discharge rose to the 50-60 CMS range and

specific conductances decreased to the 80-90 uS/cm level. During the first two weeks of June, mean daily discharge at Baring remained in the 48 to 58 CMS range, and specific conductances were in the 90-110 uS/cm range, but by June 20 daily mean discharge began to drop to the 24-30 CMS range, and as a result conductances were elevated to the 160-170 uS/cm range. Some fairly wide fluctuations in mean daily discharge (presumably due to regulation) caused some fairly wide daily fluctuations in specific conductances measured during late June and early July. By mid-July specific conductances were in the 115-130 uS/cm range and by the last week of July they were in the 100-115 uS/cm range. During the first three weeks of August, specific conductance remained in the 100-115 uS/cm range, but during the last week of August, dropped to the 65-70 uS/cm range.

Figure 37 indicates the discharge-specific conductance relationship for daily mean specific conductances measured by the AWQM at Milltown and daily mean river discharge measured by the Baring gauge. The calculated discharge-specific conductance relationship based upon a least squares fit of a logarithmetic transform of the data is also indicated on the figure. The calculated specific conductance-discharge relationship is given by the power function

specific conductance (uS/cm) = $816.04\ Q^{-0.54427}$ $r^2 = 0.904$

where Q = mean daily disch. (CMS).

A better specific conductance-discharge relationship could probably be derived from hourly discharge and AWQM data, since the hourly specific conductances measured by the AWQM exhibit wide variations on a rapidly rising or falling hydrograph.

References

Howell, G.D. 1985. 1984/85 St. Croix River Water Quality Report. Water Quality Branch, Atlantic Region Inland Waters Directorate (IWD-AR-WQB-85-89). August 1985. 31 pp.

W.Q.B. 1986. Dictionary of Parameter Codes. Water Quality Branch, Inland Waters Directorate, 332 pp.

W.Q.B. 1983. Sampling for Water Quality. Water Quality Branch, Inland Waters Directorate, 55 pp.

List of Tables

Table 1 - NAQUADAT Numbers and Site Descriptions of Stations Sampled in the St. Croix River Basin.

Table 2 - A list of parameters, parameter codes and detection limits.

Table 3 - Daily Mean Discharge of St. Croix River at Baring on Sampling Dates.

Table 4 - Temperature, Dissolved Oxygen, pH, Specific Conductance, Total Alkalinity, Turbidity and Water Color Measurements For Six St. Croix River Basin Stations Sampled During the Period May 1985 to April 1986.

Table 5 - Major Ion Concentrations (mg/L) For Six St. Croix River Basin Stations Sampled During the Period May 1985 to April 1986.

Table 6 - Major Ion Equivalent Concentrations (meq/L) For Six St. Croix River Basin Stations Sampled During the Period May 1985 to April 1986.

Table 7 - Heavy Metal Concentrations For Six St. Croix River Basin Stations Sampled During the Period May 1985 to April 1986.

Table 8 - Total Phosphorus, Total Nitrogen, Nitrite + Nitrate Nitrogen and Dissolved Organic Carbon Concentrations For Six St. Croix River Basin Stations Sampled During the Period May 1985 to April 1986.

TABLE 1: NAQUADAT Numbers and Site Descriptions of Stations Sampled on the St. Croix River.

NAQUADAT NO.	Site Description
00NB01AR0011	Forest City Stream (Grand Lake Outlet) at hwy 122, Forest City.
00NB01AR0029	Diggity Stream at hwy 630.
00NB01AR0002	St. Croix River at St. Croix - Vanceboro International Bridge.
00NB01AR0013	St. Croix River at Kellyland.
00NB01AR0014	St. Croix River, 200 m below Woodland Mill on the U.S. side of the river
00NB01AR0001	St. Croix River at Milltown hwy bridge - mid-river.

TABLE 2: A List of Parameters, Parameter Codes and Detection Limits.

Parameter	NAQUADAT Code	Detection Limit
	02061F	
	02061S	
Water Temperature	02065S	--
Dissolved Oxygen (meter)	08102S	--
Specific Conductance (field)	02042S	2 uS/cm
pH (field)	10301F	--
Specific Conductance (lab)	02041L	0.2 uS/cm
pH (lab)	10301L	--
Colour	02011L	--
Turbidity	02073L	--
Calcium	20110L	0.040 mg/L
Sodium	11103L	0.10 mg/L
Potassium	19103L	0.10 mg/L
Magnesium	12107L	0.005 mg/L
Chloride	17205L	0.100 mg/L
Sulphate	16304L	1.00 mg/L
Total Alkalinity	10101L	0.5 mg/L
Extractable Iron	26304P	0.050 mg/L
Extractable Manganese	25304P	0.010 mg/L
Extractable Copper	29305P	0.001 mg/L
Extractable Lead	82302P	0.010 mg/L
Extractable Mercury	80315P	0.02 ug/L
Extractable Aluminum	13305P	0.002 mg/L
Extractable Cadmium	48302P	0.001 mg/L
Total Phosphorus	15413P	0.005 mg/L
Total Nitrogen	07601L	0.025 mg/L
Nitrate + Nitrite N.	07110L	0.002 mg/L
Dissolved Organic Carbon	06107L	0.4 mg/L

TABLE 3: Daily Mean Discharge of St. Croix River at Baring on Sampling Dates.

Date	Daily Mean Disch. (cms)
17-May-85	34.5
25-Jul-85	23.4
15-Nov-85	64.6
07-Feb-86	72.7
25-Mar-86	64.0
23-Apr-86	93.4

List of Figures

Figure 1 - Map of Study Area

Figures 2 to 36 - Box-and-whisker plots of Hourly AWQM Data for Period February 7/86 to August 31/86.

Figure 37 - Daily Mean Specific Conductance of St. Croix River at Milltown vs Daily Mean Discharge at Baring, February 1986 - August 1986.

TABLE 4. Temperature, dissolved oxygen, pH, specific conductance, total alkalinity, and water colour measurements for six St Croix River Basin stations sampled during the period May 1985 to April 1986.

STATION	SAMPLING DATE	SAMPLING TIME	WATER TEMP. (C)	FIELD SP. COND.	LAB SP. COND.	FIELD pH	LAB pH	DISS. OXYGEN	DISS. OXYGEN	T. ALKALINITY (mg/l CaCO3)	TURB (J.T.U.)	WATER COLOUR
00NB01AR0001	17-MAY-85	1300	13.0	112	105	7.0	6.9	9.0	89.1	13.9	5.0	80
00NB01AR0001	25-JUL-85	1355	24.0		143	7.0	7.0	5.8	73.3	18.6	2.0	90
00NB01AR0001	15-NOV-85	1415	4.9	76	75		6.8	11.6	93.6	9.8	4.7	70
00NB01AR0001	07-FEB-86	1530	0.2	64	72		6.6	13.8	98.0	9.0	1.4	60
00NB01AR0001	25-MAR-86	1135	0.0		85		6.7			12.5	2.6	50
00NB01AR0001	25-MAR-86	1137			85		6.7			12.7	2.2	55
00NB01AR0001	25-MAR-86	1139			86		6.7			12.7	2.4	55
00NB01AR0001	23-APR-86	1445	8.6	60	58		6.8	10.9	96.8	8.0	2.1	55
00NB01AR0002	23-APR-86	1150	6.7		32		6.5	10.9	92.2	4.4	0.4	30
00NB01AR0011	23-APR-86	945	6.0	30	30		7.0	12.1	100.5	7.8	0.4	L5
00NB01AR0013	17-MAY-85	1125	12.5		36		6.7	10.0	97.8	7.5	1.0	35
00NB01AR0013	17-MAY-85	1130			36		6.8			7.8	0.9	35
00NB01AR0013	17-MAY-85	1135			36		6.8			7.8	0.9	35
00NB01AR0013	25-JUL-85	1155	23.0	35	34	6.9	6.7	7.3	90.3	7.5	0.6	30
00NB01AR0013	15-NOV-85	1210	4.0		41		6.7	12.6	99.3	6.7	0.8	80
00NB01AR0013	15-NOV-85	1215			42		6.7	12.6		6.7	1.0	80
00NB01AR0013	15-NOV-85	1220			42		6.6	12.6		6.5	1.0	80
00NB01AR0013	07-FEB-86	1306	0.5	28	37		6.4	14.0	100.2	5.7	0.6	45
00NB01AR0013	25-MAR-86	1140	1.0		39		6.5	11.6	84.2	8.1	0.9	35
00NB01AR0013	23-APR-86	1245	8.6		32		6.5	11.4	101.3	6.1	0.7	45
00NB01AR0014	17-MAY-85	1223	24.0	2400	2390	7.9	7.3			284.9	53.0	61000
00NB01AR0014	25-JUL-85	1331	32.0		2110	7.6					7.1	61000
00NB01AR0014	25-JUL-85	1333			2120						7.0	61000
00NB01AR0014	25-JUL-85	1335			2110						7.2	61000
00NB01AR0014	15-NOV-85	1315	18.0	2200	2260		7.6	8.4	93.3	242.8	9.7	61000
00NB01AR0014	07-FEB-86	1435			2630		7.4			336.5	40.0	61000
00NB01AR0014	07-FEB-86	1437			2620		7.5			337.7	39.0	61000
00NB01AR0014	07-FEB-86	1430	15.0	2000	2620		7.3	8.2	85.1	334.0	42.0	61000
00NB01AR0014	25-MAR-86	1500	17.0		2780		7.7	8.0	86.9		45.0	61000
00NB01AR0014	23-APR-86	1340	18.2	2000	2380			8.2	91.5		7.0	61000
00NB01AR0029	23-APR-86	1115	6.7	30	30		6.0	10.7	90.5	2.7	0.5	40

TABLE 5. Major ion concentrations (mg/l) for six St Croix River Basin stations sampled during the period May 1985 to April 1986

STATION	SAMPLE DATE	SAMPLE TIME	Na (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)	Cl (mg/l)	SO4 (mg/l)	HCO3 (mg/l)	SUM OF CONSTITS
00NB01AR0001	17-MAY-85	1300	13.4	5.3	0.95	0.86	14.4	11.00	16.94	54.83
00NB01AR0001	25-JUL-85	1355	17.8	7.0	1.35	1.00	24.0	10.90	22.67	74.23
00NB01AR0001	15-NOV-85	1415	8.3	4.8	0.76	0.95	8.7	8.60	11.95	38.43
00NB01AR0001	07-FEB-86	1530	7.5	4.3	0.78	0.87	8.4	8.10	10.97	35.58
00NB01AR0001	25-MAR-86	1135	9.5	4.6	0.73	0.84	10.5	8.40	15.24	42.34
00NB01AR0001	25-MAR-86	1137	9.4	4.7	0.72	0.84	10.8	8.40	15.48	42.93
00NB01AR0001	25-MAR-86	1139	9.3	4.6	0.72	0.84	10.7	8.60	15.48	42.87
00NB01AR0001	23-APR-86	1445	6.2	3.4	0.57	0.68	6.9	6.50	9.75	29.36
00NB01AR0002	23-APR-86	1150	1.8	3.0	0.41	0.52	2.9	3.70	5.36	15.15
00NB01AR0011	23-APR-86	945	0.9	3.6	0.28	0.57	1.4	3.20	9.51	14.72
00NB01AR0013	17-MAY-85	1125	1.5	4.0	0.35	0.83	1.9	4.00	9.14	17.17
00NB01AR0013	17-MAY-85	1130	1.5	4.0	0.40	0.86	1.9	3.80	9.51	17.19
00NB01AR0013	17-MAY-85	1135	1.5	4.0	0.35	0.85	1.9	3.75	9.51	17.08
00NB01AR0013	25-JUL-85	1155	1.7	3.4	0.35	0.75	1.6	3.40	9.14	15.75
00NB01AR0013	15-NOV-85	1210	2.0	4.8	0.59	1.10	2.7	6.20	8.17	21.68
00NB01AR0013	15-NOV-85	1215	1.9	4.9	0.53	1.10	2.7	6.20	8.17	21.62
00NB01AR0013	15-NOV-85	1220	1.8	4.9	0.50	1.10	2.8	6.00	7.92	21.27
00NB01AR0013	07-FEB-86	1306	1.7	3.9	0.46	0.86	2.9	5.20	6.95	18.62
00NB01AR0013	25-MAR-86	1140	1.6	4.2	0.39	0.88	2.3	4.80	9.88	19.57
00NB01AR0013	23-APR-86	1245	1.4	3.4	0.41	0.73	2.2	3.80	7.44	15.69
00NB01AR0014	17-MAY-85	1223	480.0	62.0	25.00	5.40	460.0	242.50	347.29	1454.17
00NB01AR0014	25-JUL-85	1331	400.0	63.0	21.50	5.00	430.0	140.00		1067.47
00NB01AR0014	25-JUL-85	1333	390.0	64.0	22.00	5.00	430.0	140.00		1061.19
00NB01AR0014	25-JUL-85	1335	390.0	63.0	22.50	5.00	430.0	140.00		1062.02
00NB01AR0014	15-NOV-85	1315	430.0	54.0	23.10	4.80	420.0	257.00	295.97	1345.33
00NB01AR0014	07-FEB-86	1435	511.0	62.0	29.00	5.50	500.0	252.00	410.19	1576.62
00NB01AR0014	07-FEB-86	1437	511.0	62.0	37.00	5.50	500.0	252.00	411.66	1588.45
00NB01AR0014	07-FEB-86	1430	485.0	62.0	27.00	5.80	500.0	250.00	407.15	1544.09
00NB01AR0014	25-MAR-86	1500	355.0	63.0	24.00	5.40	520.0			1195.21
00NB01AR0014	23-APR-86	1340	437.0	57.0	18.20	5.50	450.0	237.80	3.29	1221.00
00NB01AR0029	23-APR-86	1115	2.1	2.2	0.43	0.41	3.5	3.70		14.18

TABLE 6 . Major ion equivalent concentrations (meq/l) for six St Croix River Basin stations sampled during the period May 1985 to April 1986.

STATION	SAMPLING DATE	Na meq/l	Ca meq/l	K meq/l	Mg meq/l	Cl meq/l	SO4 meq/l	HCO3 meq/l
00NB01AR0001	17-MAY-85	0.5829	0.2645	0.0243	0.0707	0.4062	0.2290	0.2777
00NB01AR0001	25-JUL-85	0.7743	0.3493	0.0345	0.0823	0.6770	0.2269	0.3716
00NB01AR0001	15-NOV-85	0.3611	0.2395	0.0194	0.0781	0.2454	0.1791	0.1958
00NB01AR0001	07-FEB-86	0.3263	0.2146	0.0199	0.0716	0.2370	0.1686	0.1798
00NB01AR0001	25-MAR-86	0.4133	0.2295	0.0187	0.0691	0.2962	0.1749	0.2497
00NB01AR0001	25-MAR-86	0.4089	0.2345	0.0184	0.0691	0.3047	0.1749	0.2537
00NB01AR0001	25-MAR-86	0.4046	0.2295	0.0184	0.0691	0.3018	0.1791	0.2537
00NB01AR0001	23-APR-86	0.2697	0.1697	0.0146	0.0559	0.1946	0.1353	0.1598
00NB01AR0002	23-APR-86	0.0783	0.1497	0.0105	0.0428	0.0818	0.0770	0.0879
00NB01AR0011	23-APR-86	0.0392	0.1796	0.0072	0.0469	0.0395	0.0666	0.1558
00NB01AR0013	17-MAY-85	0.0653	0.1996	0.0090	0.0683	0.0536	0.0833	0.1498
00NB01AR0013	17-MAY-85	0.0653	0.1996	0.0102	0.0707	0.0536	0.0791	0.1558
00NB01AR0013	17-MAY-85	0.0653	0.1996	0.0090	0.0699	0.0536	0.0781	0.1558
00NB01AR0013	25-JUL-85	0.0740	0.1697	0.0090	0.0617	0.0451	0.0708	0.1498
00NB01AR0013	15-NOV-85	0.0870	0.2395	0.0151	0.0905	0.0762	0.1291	0.1339
00NB01AR0013	15-NOV-85	0.0827	0.2445	0.0136	0.0905	0.0762	0.1291	0.1339
00NB01AR0013	15-NOV-85	0.0783	0.2445	0.0128	0.0905	0.0790	0.1249	0.1299
00NB01AR0013	07-FEB-86	0.0740	0.1946	0.0118	0.0707	0.0818	0.1083	0.1139
00NB01AR0013	25-MAR-86	0.0696	0.2096	0.0100	0.0724	0.0649	0.0999	0.1618
00NB01AR0013	23-APR-86	0.0609	0.1697	0.0105	0.0601	0.0621	0.0791	0.1219
00NB01AR0014	17-MAY-85	21	3.0938	0.6393	0.4442	13	5.0489	5.6921
00NB01AR0014	25-JUL-85	17	3.1437	0.5498	0.4113	12	2.9148	
00NB01AR0014	25-JUL-85	17	3.1936	0.5625	0.4113	12	2.9148	
00NB01AR0014	25-JUL-85	17	3.1437	0.5753	0.4113	12	2.9148	
00NB01AR0014	15-NOV-85	19	2.6946	0.5907	0.3948	12	5.3507	4.8510
00NB01AR0014	07-FEB-86	22	3.0938	0.7415	0.4524	14	5.2466	6.7231
00NB01AR0014	07-FEB-86	22	3.0938	0.9461	0.4524	14	5.2466	6.7470
00NB01AR0014	07-FEB-86	21	3.0938	0.6904	0.4771	14	5.2050	6.6731
00NB01AR0014	25-MAR-86	24	3.1437	0.6137	0.4442	15	0.4685	
00NB01AR0014	23-APR-86	19	2.8443	0.4654	0.4524	13	4.9510	
00NB01AR0029	23-APR-86	0.0914	0.1098	0.0110	0.0337	0.0987	0.0770	0..0539

TABLE 7 : Heavy metal concentrations for six St Croix River Basin stations sampled during the period May 1985 to April 1986

STATION	SAMPLING DATE	SAMPLING TIME	Fe-Ext mg/l	Mn-Ext mg/l	Cu-Ext mg/l	Pb-Ext mg/l	Al-Ext mg/l	Hg-Ext mg/l	Cd-Ext mg/l
00NB01AR0001	17-MAY-85	1300	0.21	0.10	L.002	L.002	0.170	L.02	L.001
00NB01AR0001	25-JUL-85	1355	0.33	0.14	L.002	L.002	0.140	L.02	L.001
00NB01AR0001	15-NOV-85	1415	0.14	0.03	L.002	L.002	0.160	L.02	L.001
00NB01AR0001	07-FEB-86	1530	0.16	0.06	0.002	0.002	0.150	L.02	0.001
00NB01AR0001	25-MAR-86	1139	0.14	0.07	L.002	L.002	0.120	0.02	L.001
00NB01AR0001	25-MAR-86	1137	0.19	0.07	L.002	L.002	0.410	L.02	L.001
00NB01AR0001	25-MAR-86	1135	0.16	0.07	L.002	L.002	0.100	0.02	L.001
00NB01AR0001	23-APR-86	1445	0.13	0.04	L.002	0.002	0.120	L.02	L.001
00NB01AR0002	23-APR-86	1150	0.11	0.03	L.002	L.002	0.080	L.02	L.001
00NB01AR0011	23-APR-86	945	L.05	L.01	L.002	L.002	0.020	L.02	L.001
00NB01AR0013	17-MAY-85	1125	0.10	0.02	L.002	L.002	0.066	L.02	L.001
00NB01AR0013	17-MAY-85	1130	0.10	0.01	0.003	L.002	0.078	L.02	L.001
00NB01AR0013	17-MAY-85	1135	0.10	0.02	L.002	L.002	0.075	L.02	L.001
00NB01AR0013	25-JUL-85	1155	0.20	0.05	L.002	0.002	0.050	L.02	L.001
00NB01AR0013	15-NOV-85	1210	0.16	0.01	L.002	L.002	0.130	L.02	L.001
00NB01AR0013	15-NOV-85	1215	0.20	0.02	L.002	L.002	0.130	L.02	L.001
00NB01AR0013	15-NOV-85	1220	0.13	0.02	L.002	L.002	0.130	L.02	L.001
00NB01AR0013	07-FEB-86	1306	0.14	0.02	L.002	L.002	0.088	L.02	L.001
00NB01AR0013	25-MAR-86	1140	0.12	0.02	L.002	L.002	0.068	L.02	L.001
00NB01AR0013	23-APR-86	1245	0.12	0.02	L.002	L.002	0.085	L.02	L.001
00NB01AR0013	23-APR-86	1235	0.15	0.01	L.002	L.002	0.091	L.02	L.001
00NB01AR0013	23-APR-86	1240	0.15	0.02	L.002	L.002	0.097	L.02	L.001
00NB01AR0014	17-MAY-85	1223	0.85	1.90	0.010	0.008	5.0	L.02	0.003
00NB01AR0014	25-JUL-85	1331	0.88	2.00	0.007	0.006	2.0	L.02	0.002
00NB01AR0014	25-JUL-85	1333	0.82	2.00	0.005	0.010	2.0	L.02	0.002
00NB01AR0014	25-JUL-85	1335	0.82	2.00	0.006	0.008	1.9	L.02	0.002
00NB01AR0014	15-NOV-85	1315	0.26	1.40	0.007	0.006	2.4	L.02	0.002
00NB01AR0014	07-FEB-86	1430	0.52	2.20	0.003	0.003	3.2	0.02	0.002
00NB01AR0014	07-FEB-86	1435	0.51	2.20	0.002	0.004	3.1	0.02	0.001
00NB01AR0014	07-FEB-86	1437	0.52	2.20	0.002	0.003	3.1	L.02	0.009
00NB01AR0014	25-MAR-86	1500	0.56	2.40	0.002	0.005	3.1	0.04	0.002
00NB01AR0014	23-APR-86	1340	0.69	2.50	0.009	0.008	3.1	0.03	0.007
00NB01AR0029	23-APR-86	1115	0.18	0.04	L.002	L.002	0.12	L.02	L.001

TABLE 8 . Total phosphorus, nitrate + nitrite nitrogen, total nitrogen and dissolved organic carbon concentrations for six St Croix River Basin stations sampled during the period May 1985 to April 1986.

STATION	SAMPLING DATE	SAMPLING TIME	T.Phos. mg/l	T.Nitrogen mg/l	Nitrate+Nitrite N mg/l	D.O.C. mg/l
00NB01AR0001	17-MAY-85	1300	0.040	0.24	0.13	7.9
00NB01AR0001	25-JUL-85	1355	0.056	0.30	0.23	10.0
00NB01AR0001	15-NOV-85	1415	0.020	0.23	0.10	12.0
00NB01AR0001	07-FEB-86	1530	0.016	0.21	0.05	8.7
00NB01AR0001	25-MAR-86	1135	0.029	0.24	0.06	8.0
00NB01AR0001	25-MAR-86	1137	0.030	0.25	0.10	8.4
00NB01AR0001	25-MAR-86	1139	0.028	0.24	0.11	8.0
00NB01AR0001	23-APR-86	1445	0.029	0.19	0.07	6.5
00NB01AR0002	23-APR-86	1150	0.011	0.22	0.04	6.2
00NB01AR0011	23-APR-86	945	0.005	0.12	0.02	3.2
00NB01AR0013	17-MAY-85	1125	0.009	0.10	0.02	8.9
00NB01AR0013	17-MAY-85	1130	0.009	0.10	0.01	9.0
00NB01AR0013	17-MAY-85	1135	0.009	0.10	0.01	8.0
00NB01AR0013	25-JUL-85	1155	0.010	0.12	L.01	8.2
00NB01AR0013	15-NOV-85	1210	0.005	0.16	0.06	13.0
00NB01AR0013	15-NOV-85	1215	0.006	0.17	0.06	13.0
00NB01AR0013	15-NOV-85	1220	0.003	0.18	0.06	14.0
00NB01AR0013	07-FEB-86	1306	0.007	0.20	0.04	7.3
00NB01AR0013	25-MAR-86	1140		0.23	0.12	6.5
00NB01AR0013	23-APR-86	1245	0.009	0.18	0.02	7.2
00NB01AR0014	17-MAY-85	1223		3.80	1.85	110.0
00NB01AR0014	25-JUL-85	1331		2.80	1.80	70.0
00NB01AR0014	25-JUL-85	1333		3.00	2.30	87.0
00NB01AR0014	25-JUL-85	1335		3.30	2.60	80.0
00NB01AR0014	15-NOV-85	1315		3.40	2.40	85.0
00NB01AR0014	23-APR-86	1340		3.60	3.50	96.0
00NB01AR0029	23-APR-86	1115	0.015	0.21	0.05	7.5

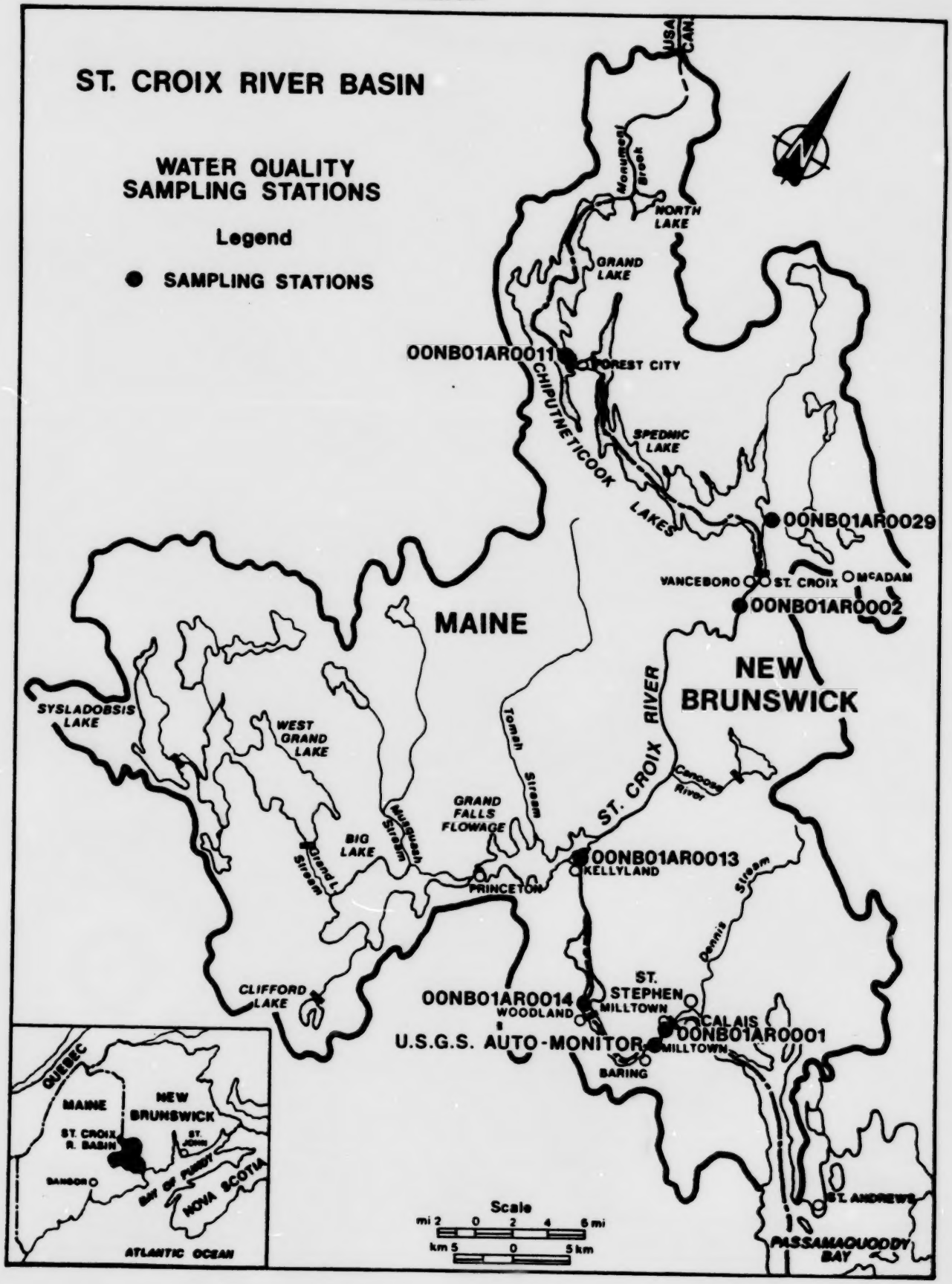

ST. CROIX RIVER BASIN
WATER QUALITY SAMPLING STATIONS
Legend
SAMPLING STATIONS
USA
CAN
Monument Brook
NORTH LAKE
GRAND LAKE
00NB01AR0011
FOREST CITY
CHIPUTNETICOOK LAKES
SPEDNIC LAKE
00NB01AR0029
VANCEBORO
ST. CROIX
McADAM
00NB01AR0002
MAINE
NEW BRUNSWICK
ST. CROIX RIVER
SYSLADOBSIS LAKE
WEST GRAND LAKE
Tomah Stream
Canoose River
GRAND FALLS FLOWAGE
Musquash Stream
BIG LAKE
Grand L. Stream
00NB01AR0013
KELLYLAND
PRINCETON
Dennis Stream
CLIFFORD LAKE
00NB01AR0014
WOODLAND
ST. STEPHEN
MILLTOWN
CALAIS
00NB01AR0001
U.S.G.S. AUTO-MONITOR
MILLTOWN
BARING
ST. ANDREWS
PASSAMAQUODDY BAY
Scale
mi 2 0 2 4 6 mi
km 5 0 5 km
QUEBEC
MAINE
NEW BRUNSWICK
ST. CROIX R. BASIN
ST. JOHN
BANGOR
BAY OF FUNDY
NOVA SCOTIA
ATLANTIC OCEAN

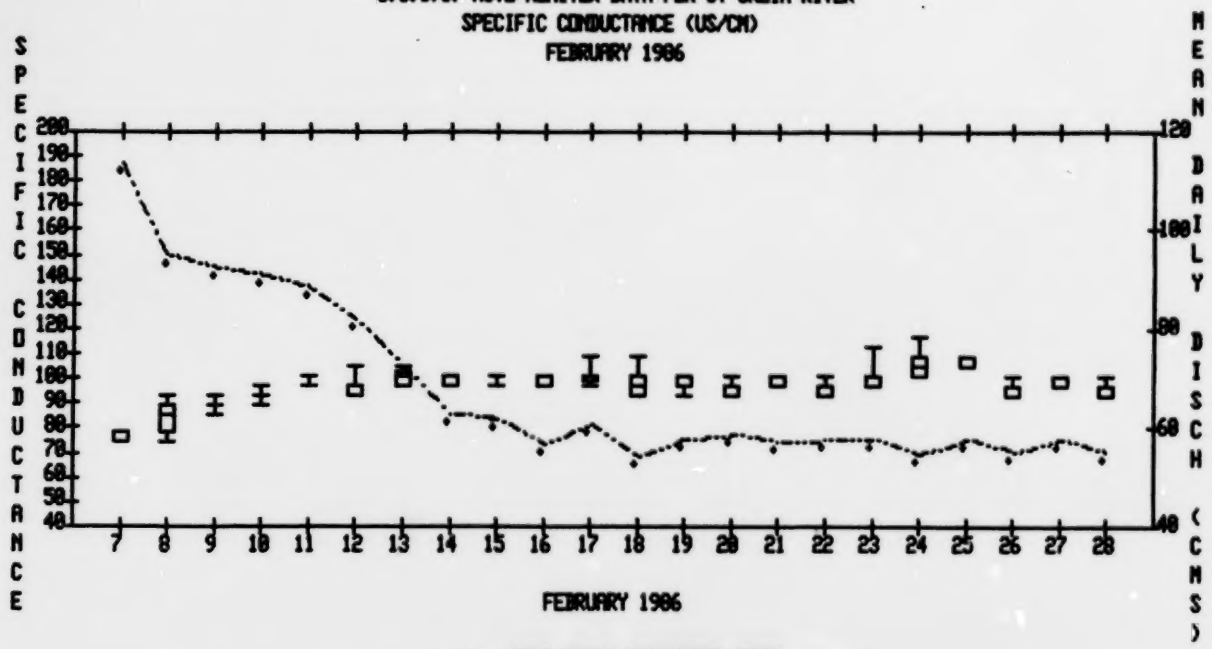
Figure 1

FIG. 2

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

SPECIFIC CONDUCTANCE (US/CM)

FEBRUARY 1986



NOTE:PROVISIONAL DATA ONLY

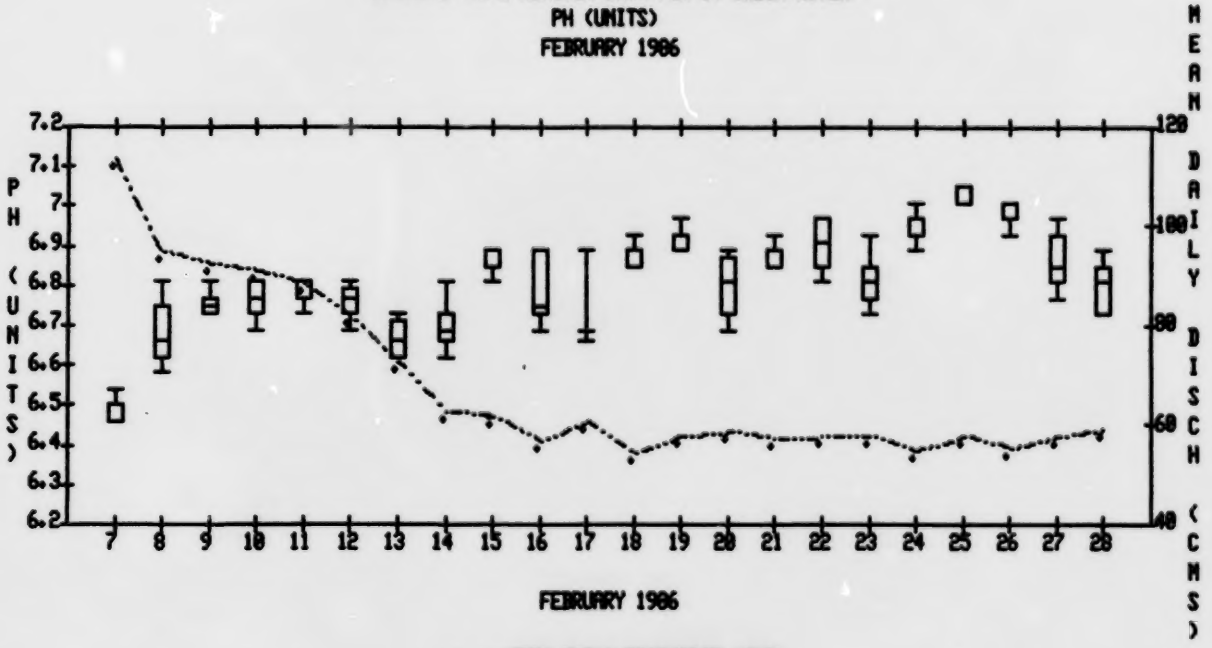
MONITOR REPORTED 583 OUT OF A POSSIBLE 672 READINGS

FIG. 3

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

PH (UNITS)

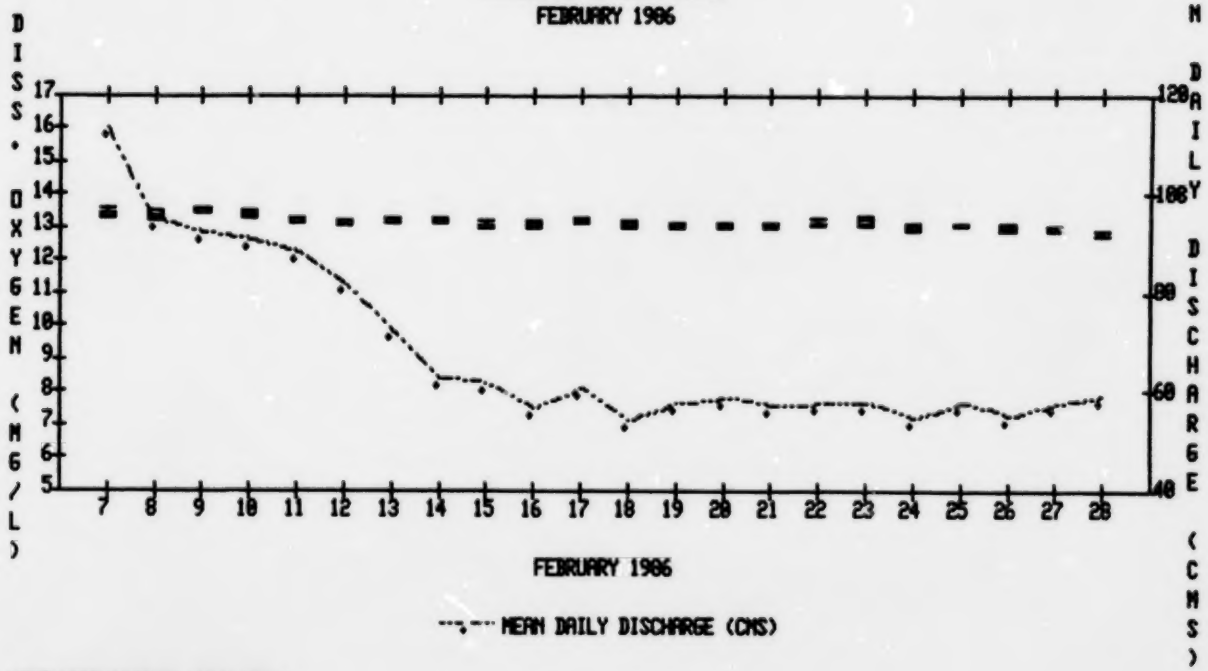
FEBRUARY 1986



NOTE:PROVISIONAL DATA ONLY

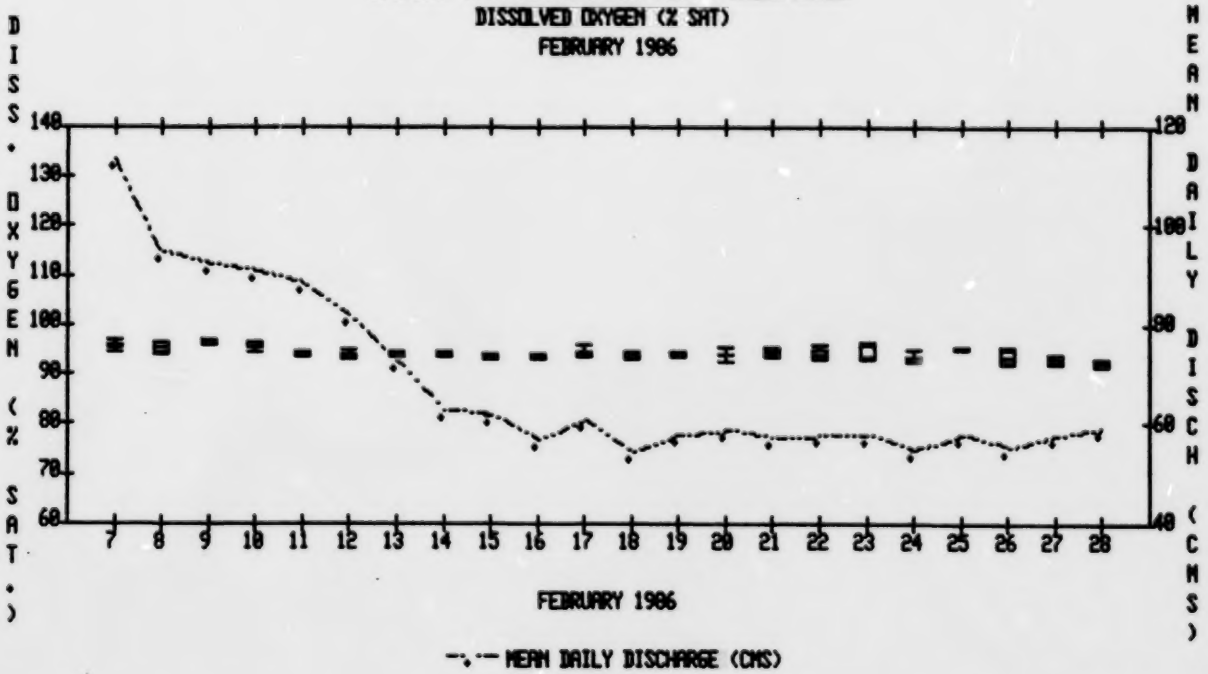
MONITOR REPORTED 582 READINGS OUT OF A POSSIBLE 672

FIG. 4
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (MG/L)
FEBRUARY 1986



NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 501 READINGS OUT OF A POSSIBLE 672

FIG. 5
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (% SAT)
FEBRUARY 1986



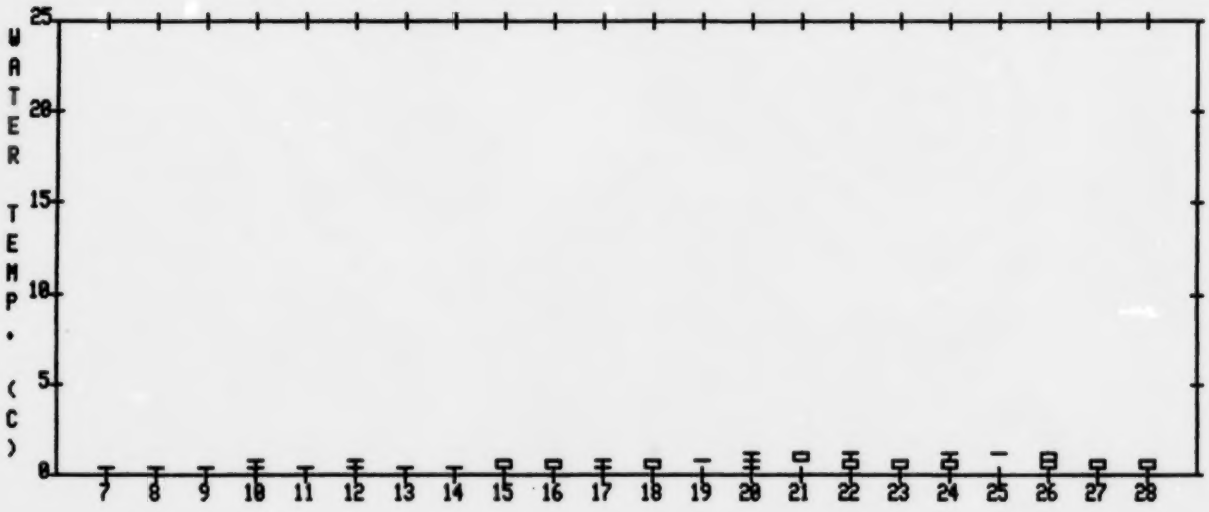
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 501 TIMES OUT OF A POSSIBLE 672

FIG. 6

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

WATER TEMPERATURE (C)

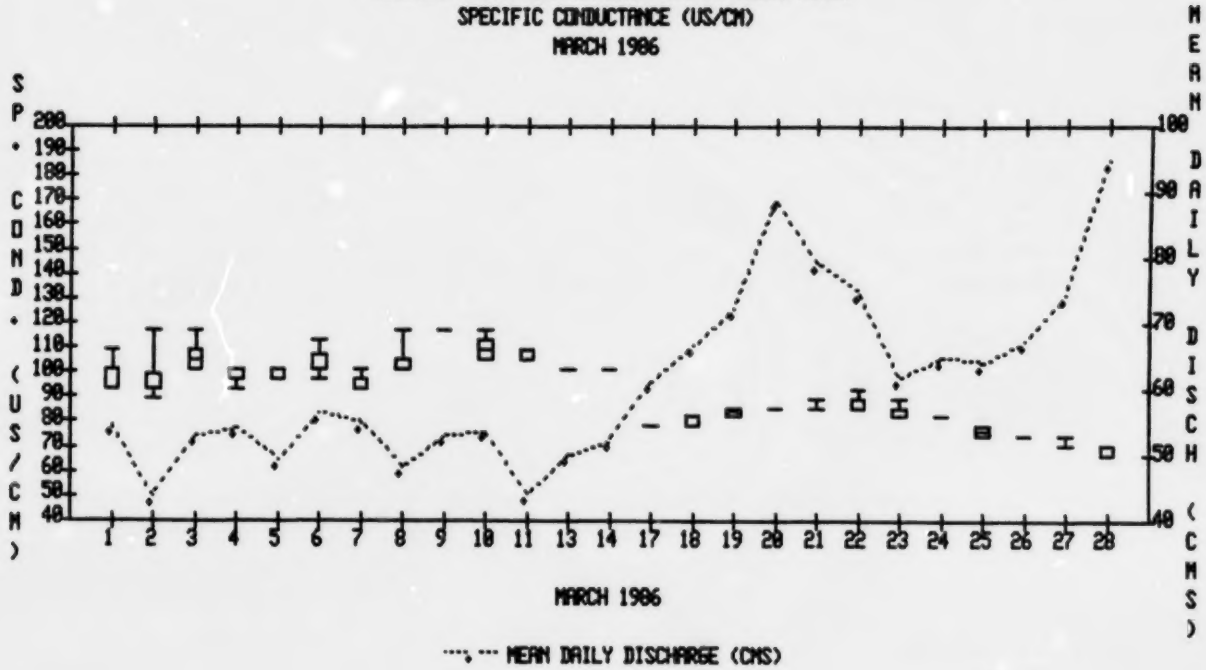
FEBRUARY 1986



NOTE:PROVISIONAL DATA ONLY

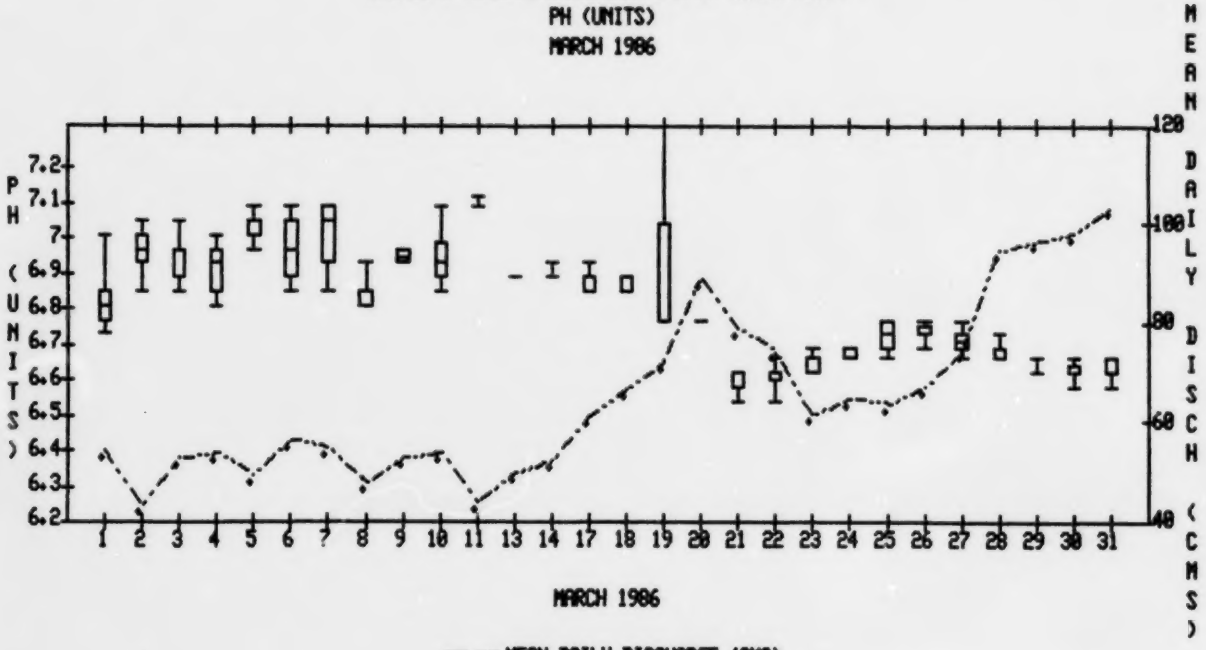
MONITOR REPORTED 583 READINGS OUT OF A POSSIBLE 672

FIG. 7
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
SPECIFIC CONDUCTANCE (US/CM)
MARCH 1986



NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 424 READINGS OUT OF A POSSIBLE 744

FIG. 8
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
PH (UNITS)
MARCH 1986



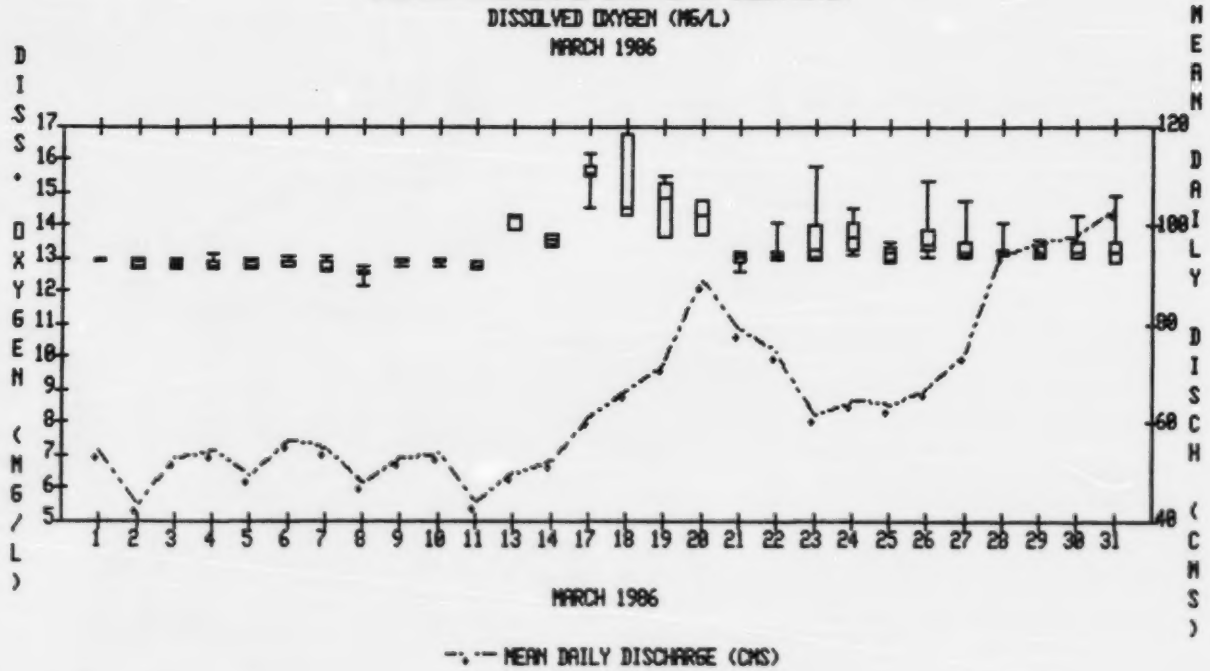
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 509 READINGS OUT OF A POSSIBLE 744

FIG. 9

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

DISSOLVED OXYGEN (MG/L)

MARCH 1986



NOTE:PROVISIONAL DATA ONLY

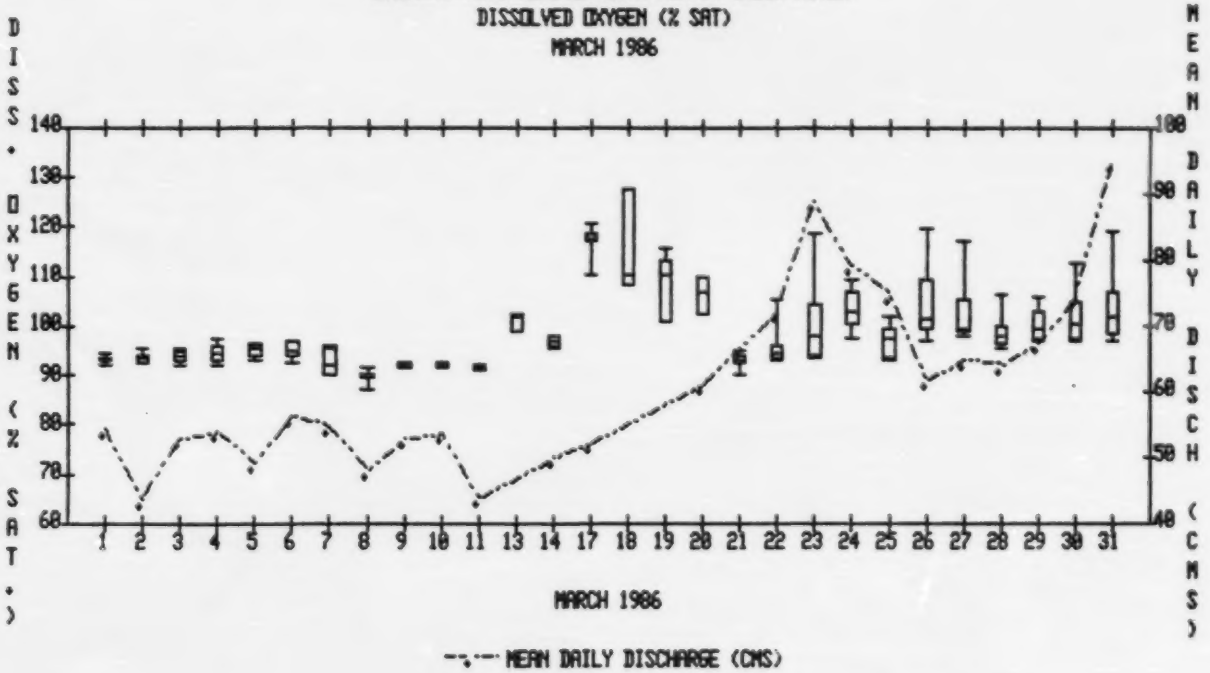
MONITOR REPORTED 509 READINGS OUT OF A POSSIBLE 744

FIG. 10

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

DISSOLVED OXYGEN (% SAT)

MARCH 1986



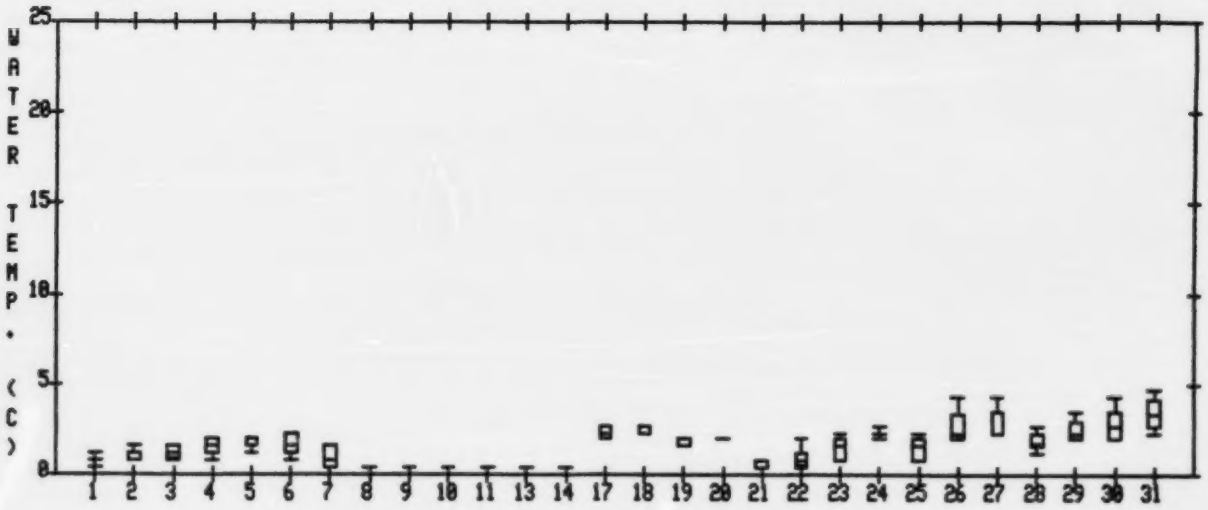
NOTE:PROVISIONAL DATA ONLY

FIG. 11

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

WATER TEMPERATURE (C)

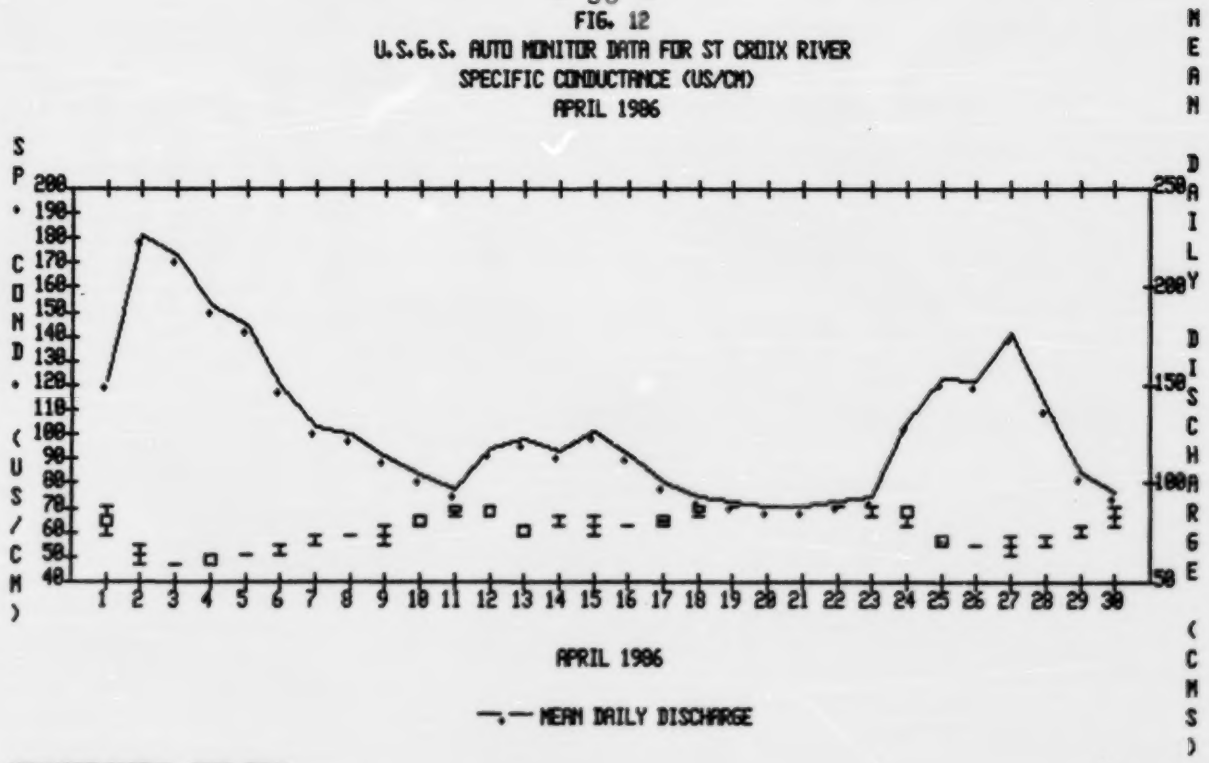
MARCH 1986



NOTE:PROVISIONAL DATA ONLY

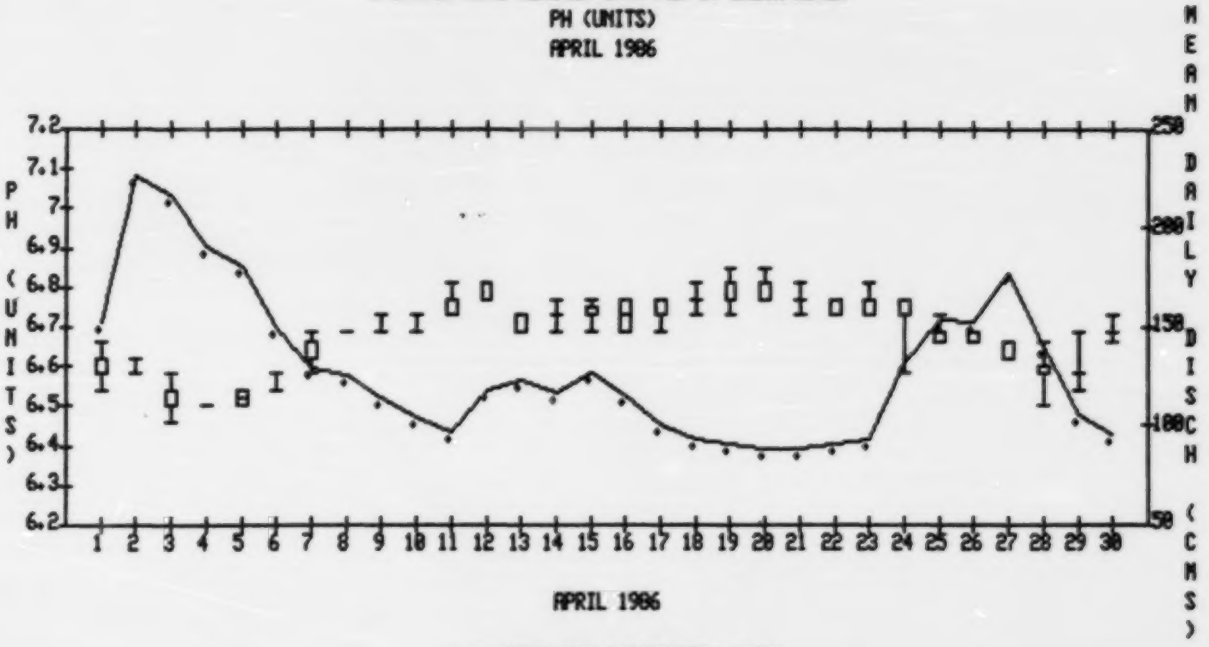
MONITOR REPORTED 589 READINGS OUT OF A POSSIBLE 744

FIG. 12
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
SPECIFIC CONDUCTANCE (US/CM)
APRIL 1986



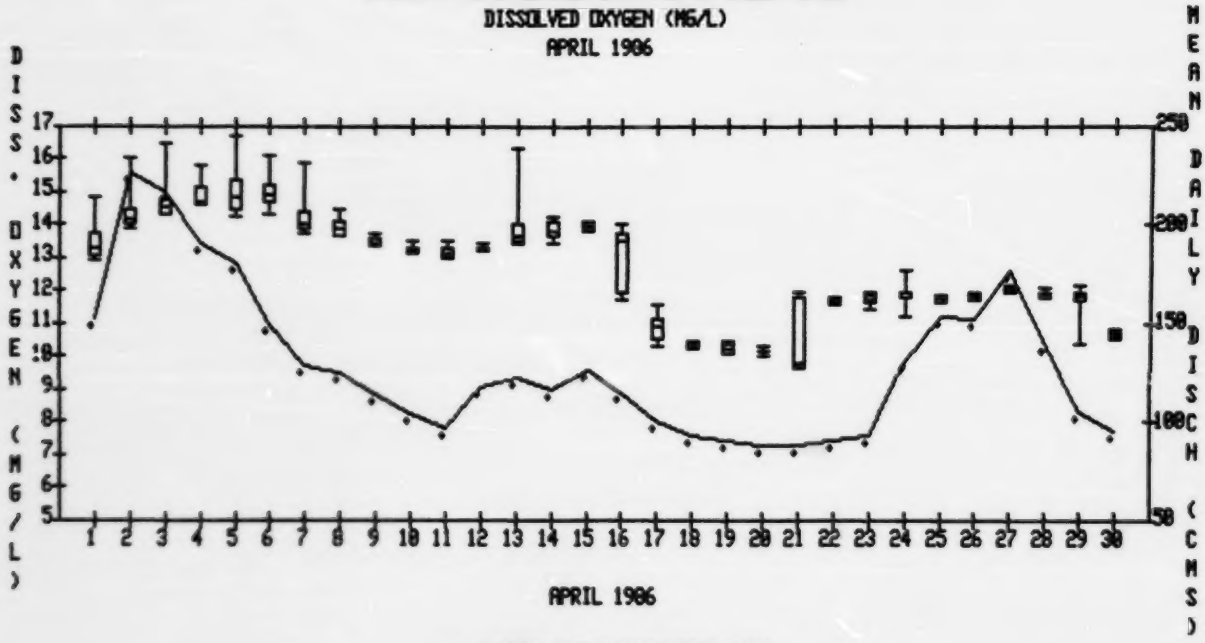
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 643 READINGS OUT OF A POSSIBLE 720

FIG. 13
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
PH (UNITS)
APRIL 1986



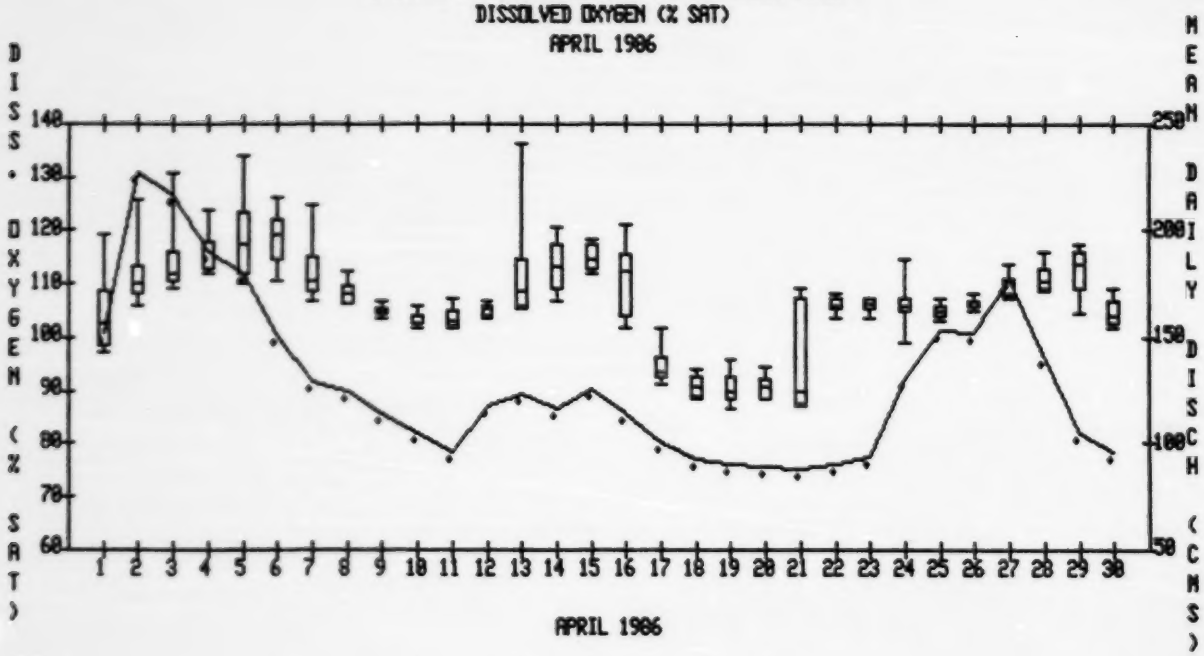
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 643 READINGS OUT OF A POSSIBLE 720

FIG. 14
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (MG/L)
APRIL 1986



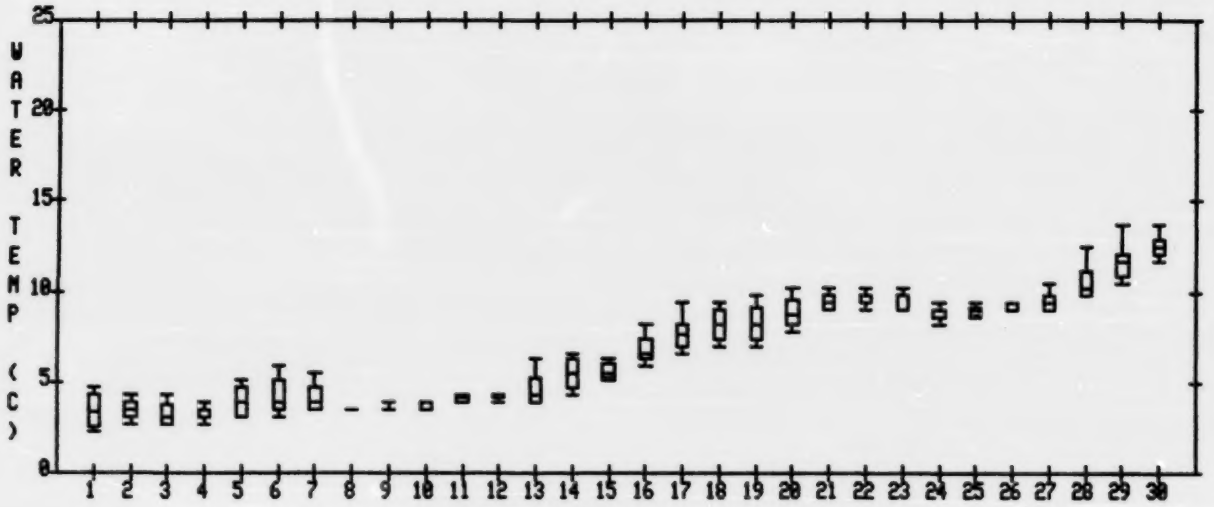
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 640 READINGS OUT OF A POSSIBLE 720

FIG. 15
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (% SAT)
APRIL 1986



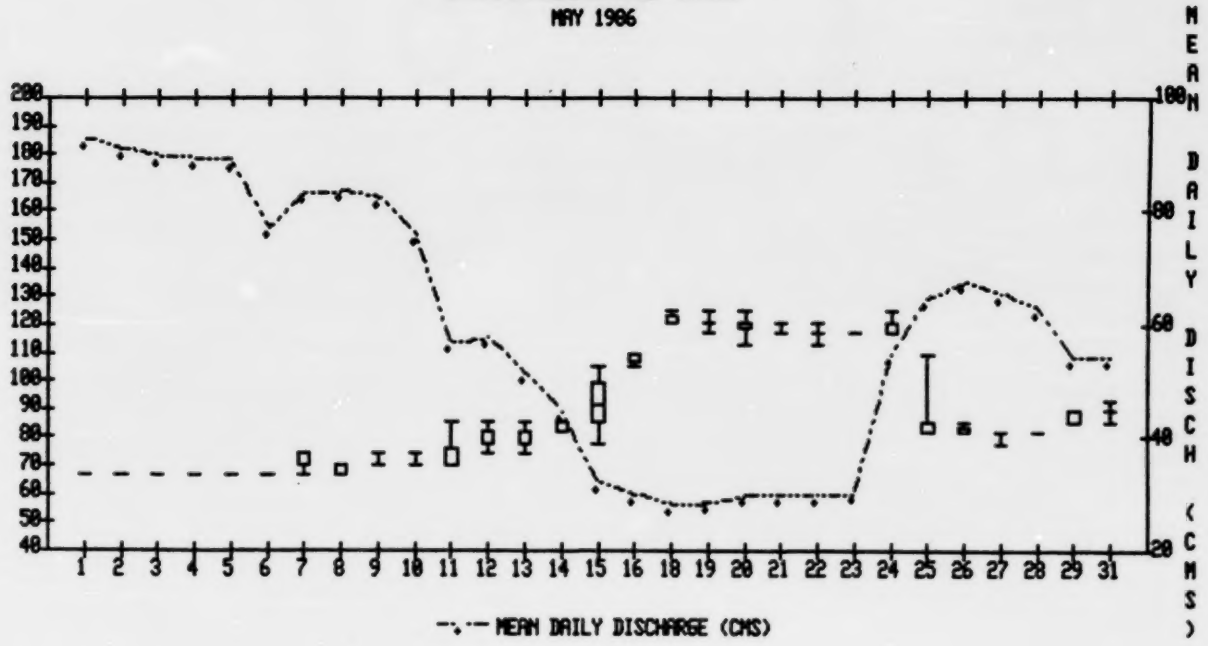
NOTE:PROVISIONAL DATA ONLY

FIG. 16
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
WATER TEMPERATURE (C)
APRIL 1986



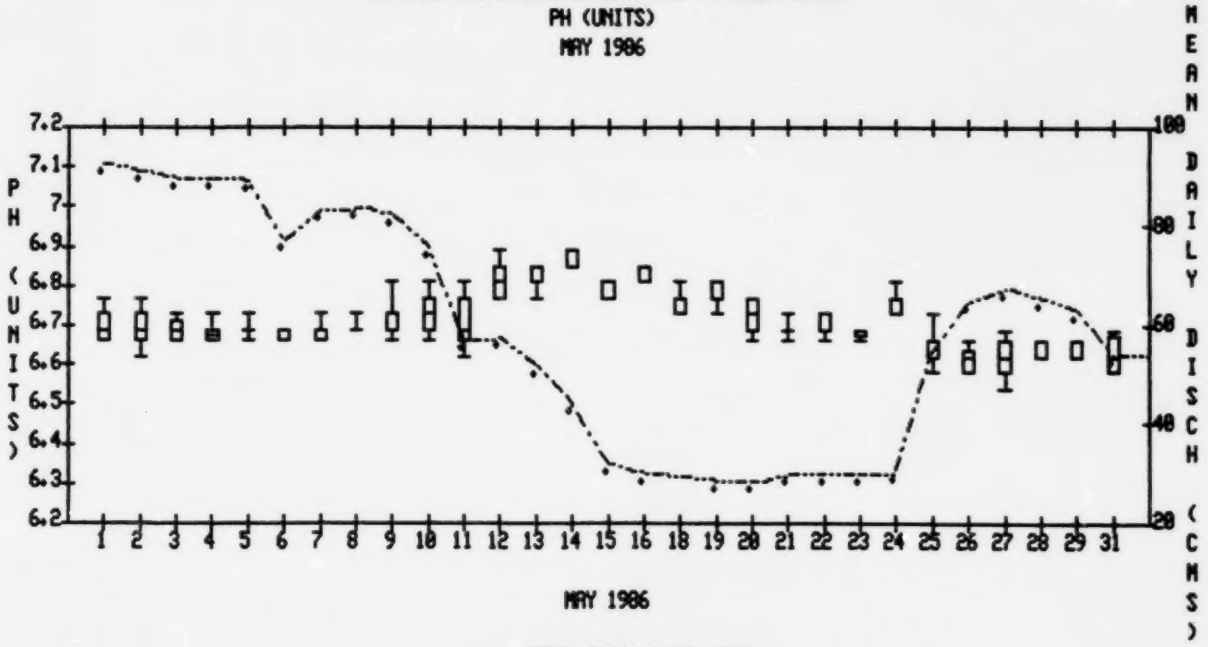
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 642 READINGS OUT OF A POSSIBLE 720

FIG. 17
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
SPECIFIC CONDUCTANCE (US/CM)
MAY 1986



NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 612 READINGS OUT OF A POSSIBLE 744

FIG. 18
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
PH (UNITS)
MAY 1986



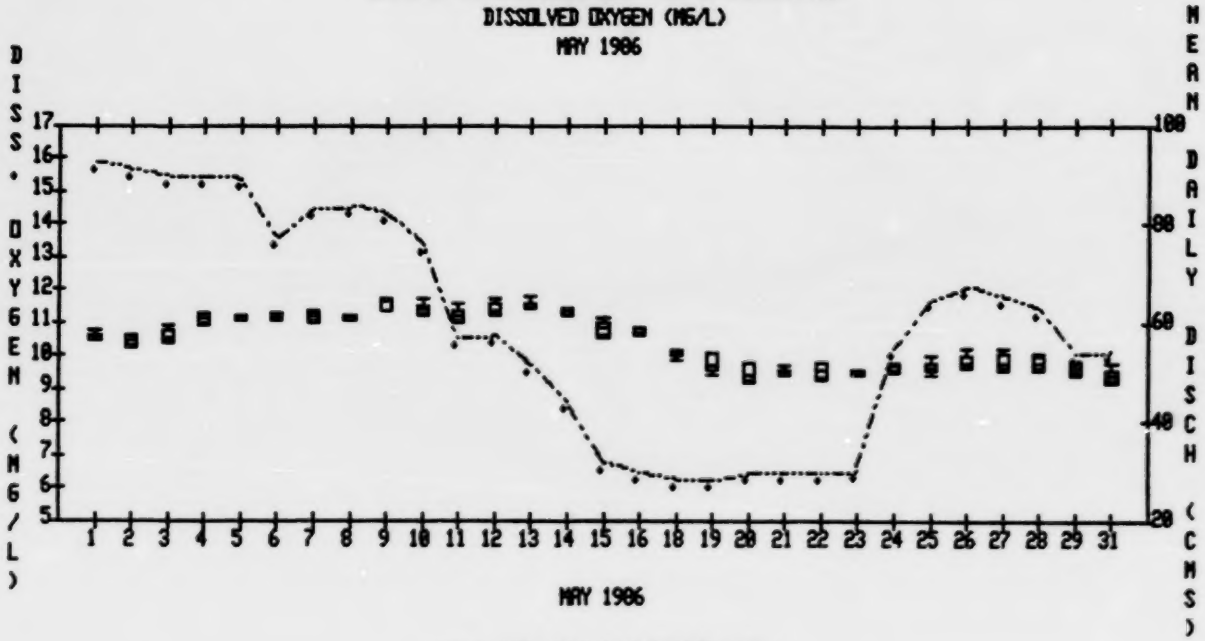
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 612 READINGS OUT OF A POSSIBLE 744

FIG. 19

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

DISSOLVED OXYGEN (MG/L)

MAY 1986



NOTE:PROVISIONAL DATA ONLY

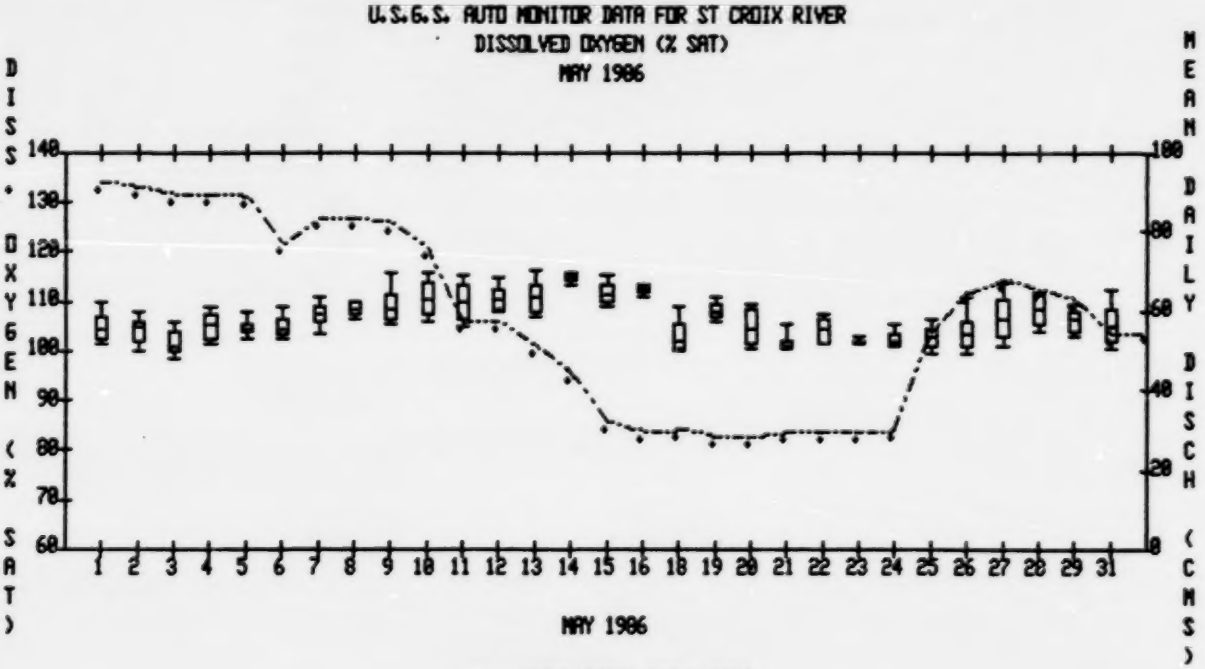
MONITOR REPORTED 612 READINGS OUT OF A POSSIBLE 744

FIG. 20

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

DISSOLVED OXYGEN (% SAT)

MAY 1986



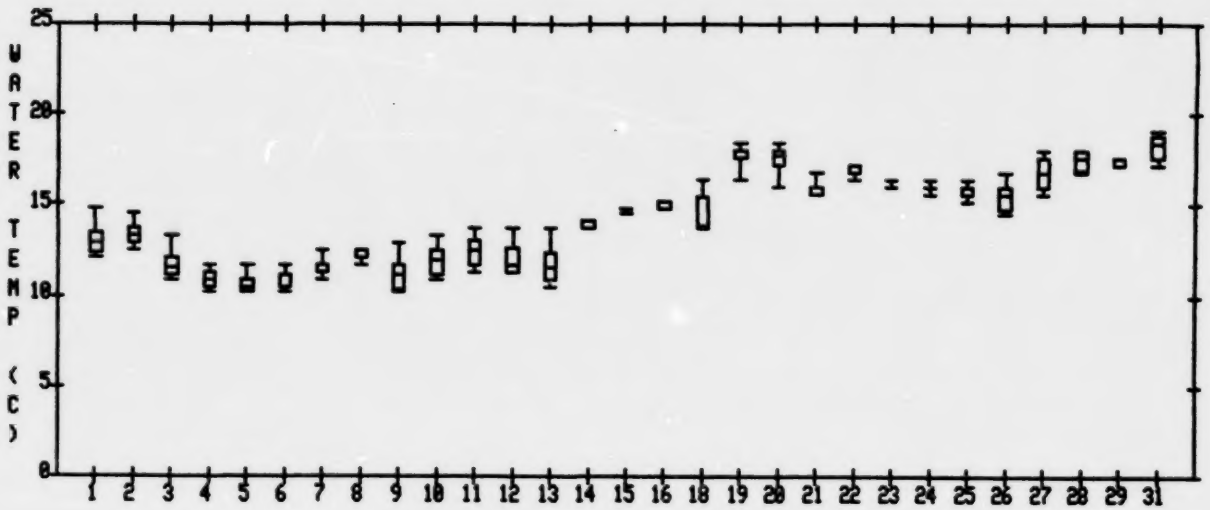
NOTE:PROVISIONAL DATA ONLY

FIG. 21

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

WATER TEMPERATURE (C)

MAY 1986

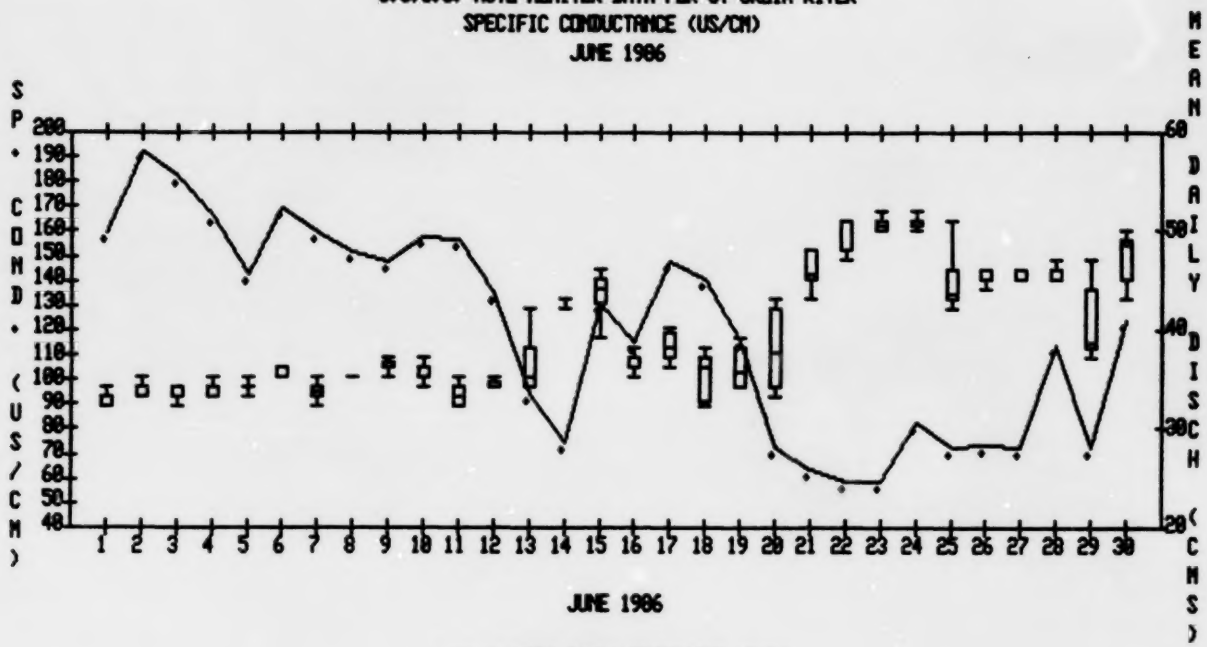


MAY 1986

NOTE:PROVISIONAL DATA ONLY

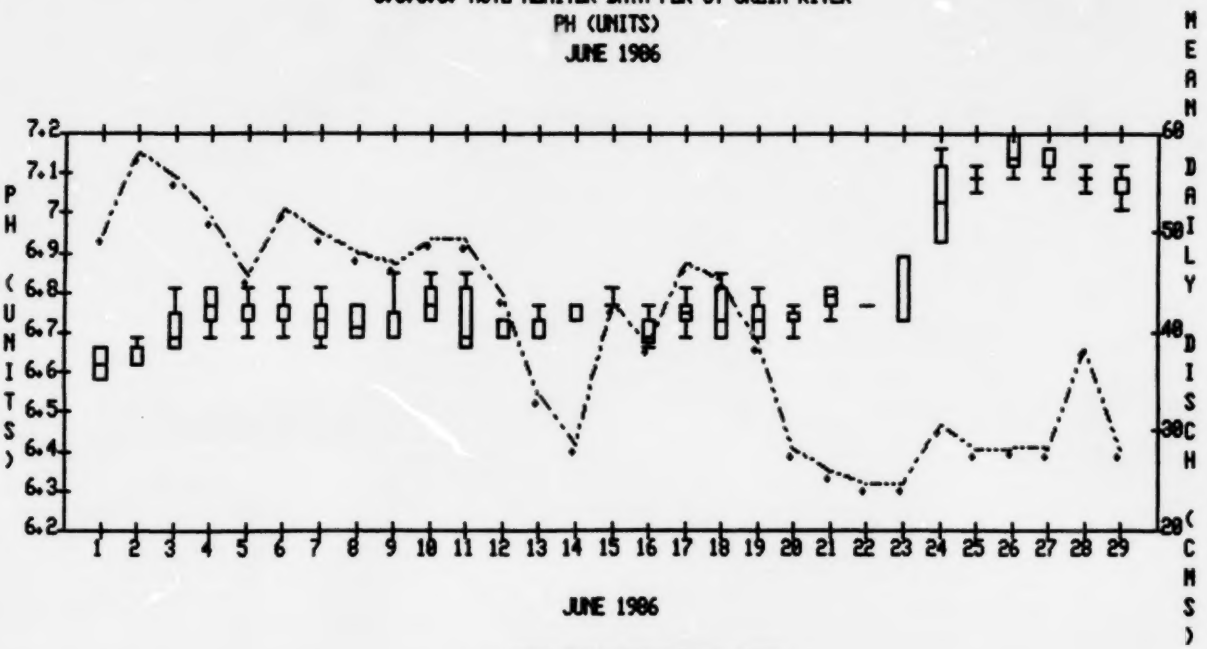
MONITOR REPORTED 612 READINGS OUT OF A POSSIBLE 744

FIG. 22
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
SPECIFIC CONDUCTANCE (US/CM)
JUNE 1986



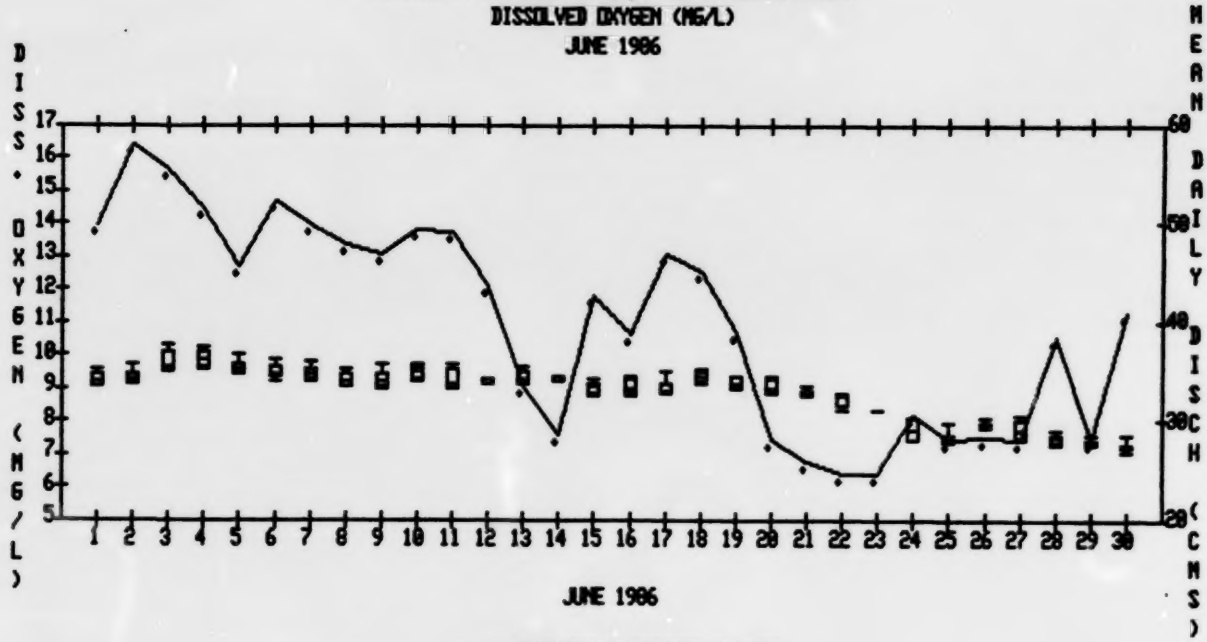
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 623 READINGS OUT OF A POSSIBLE 720

FIG. 23
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
PH (UNITS)
JUNE 1986



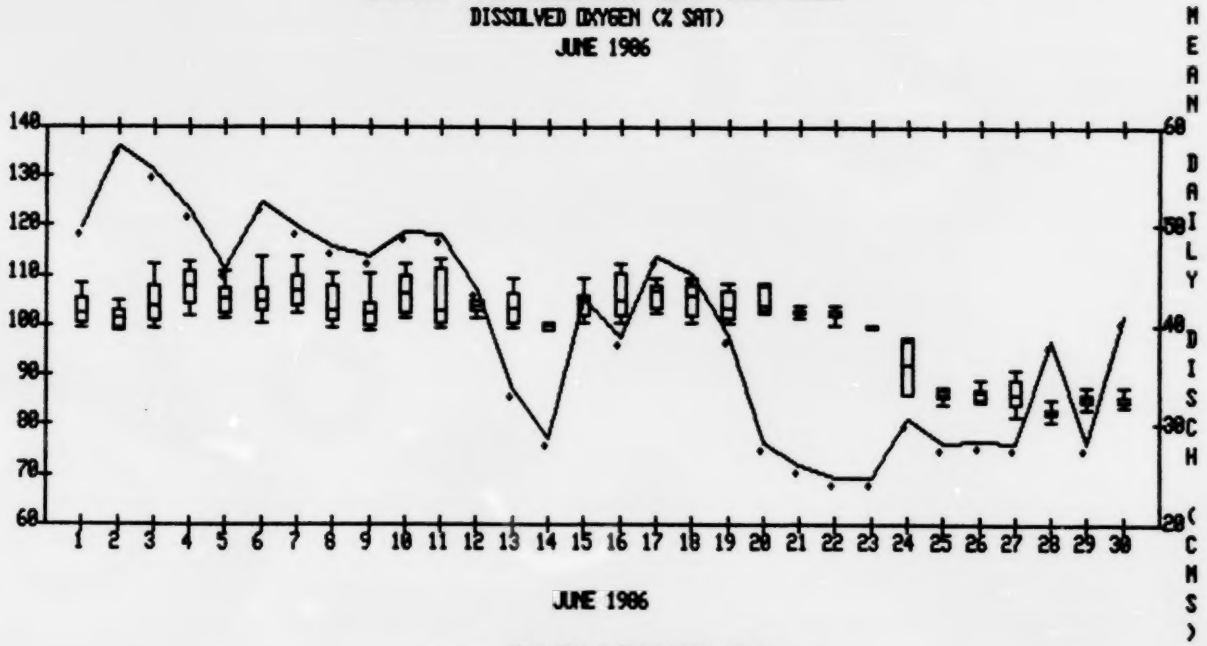
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 623 READINGS OUT OF A POSSIBLE 720

FIG. 24
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (MG/L)
JUNE 1986



NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 623 READINGS OUT OF A POSSIBLE 720

FIG. 25
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (% SAT)
JUNE 1986



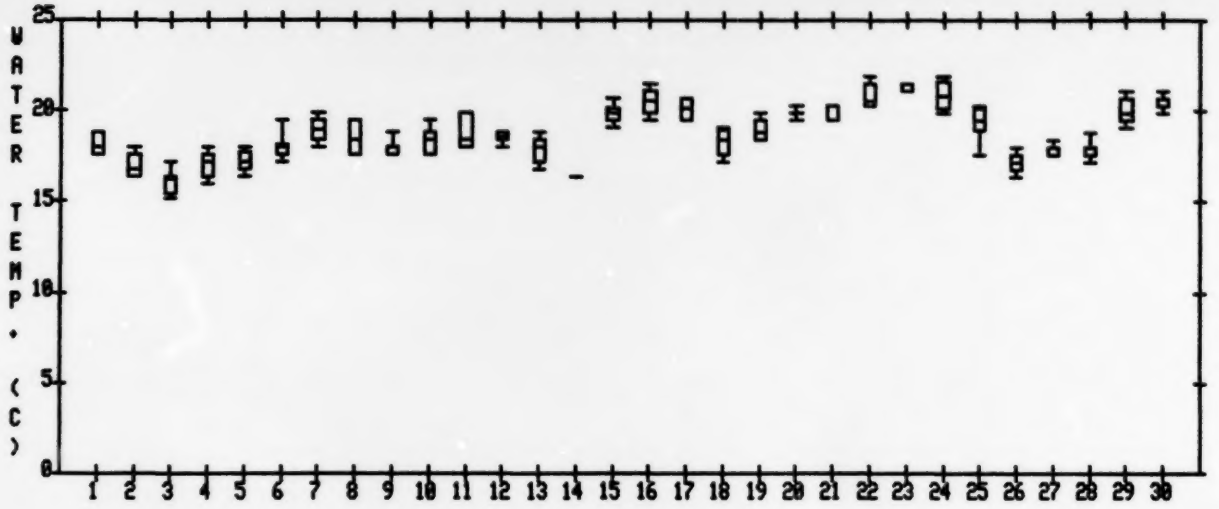
NOTE:PROVISIONAL DATA ONLY

FIG. 26

U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER

WATER TEMPERATURE (C)

JUNE 1986

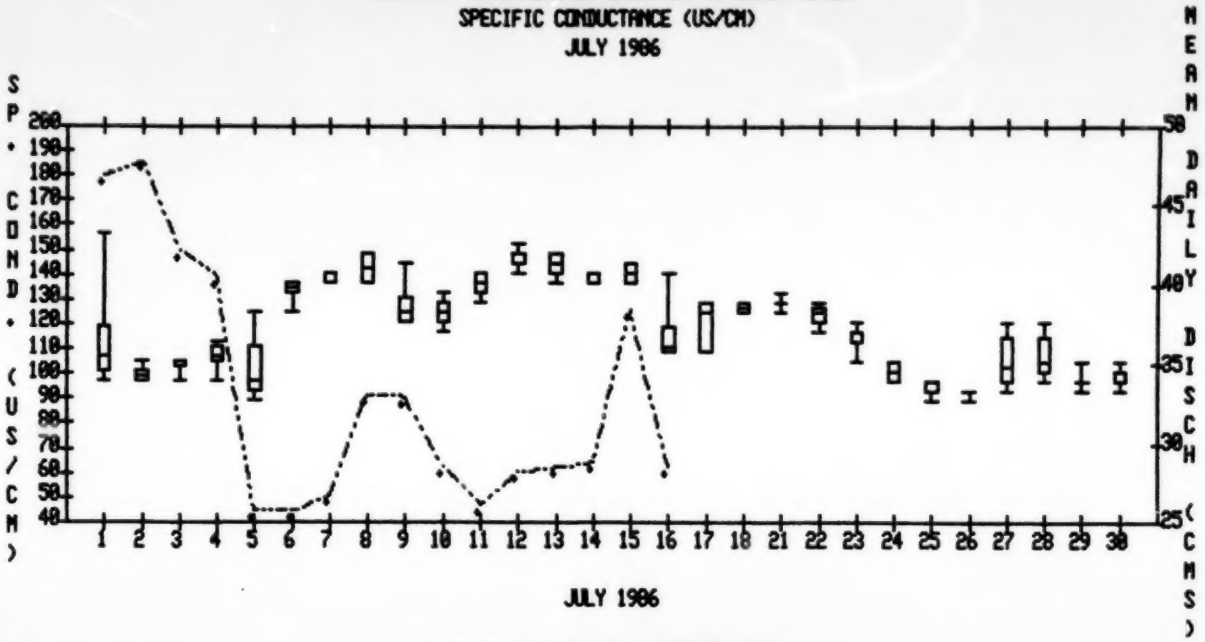


JUNE 1986

NOTE:PROVISIONAL DATA ONLY

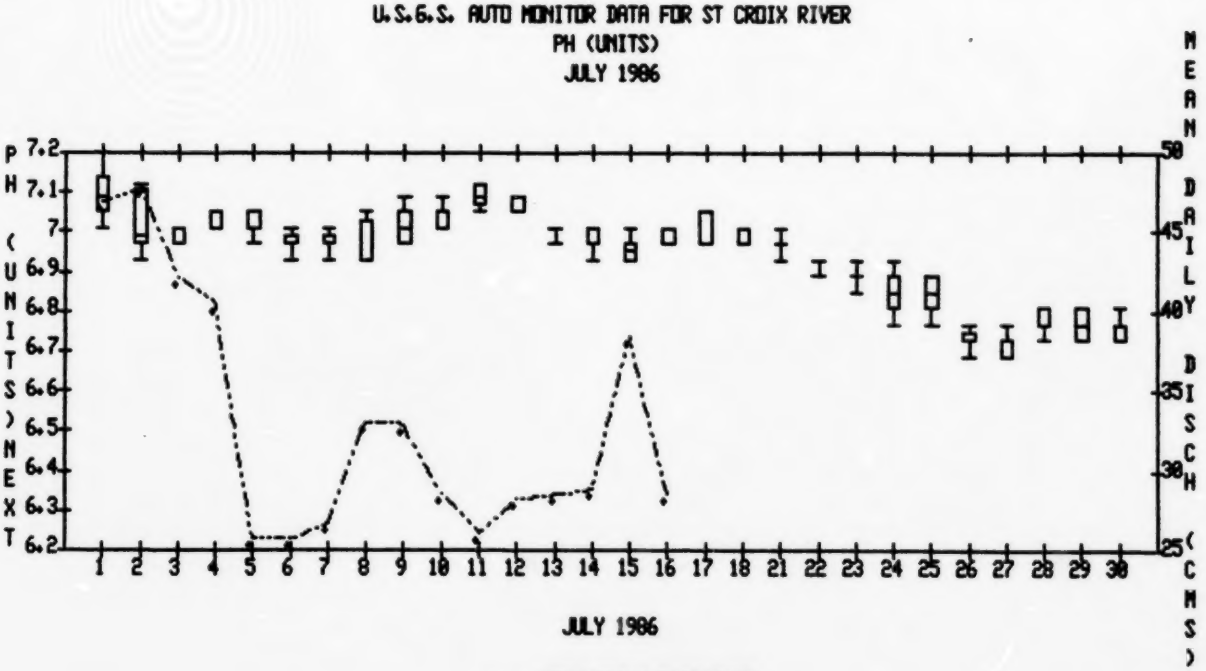
MONITOR REPORTED 623 READINGS OUT OF A POSSIBLE 720

FIG. 27
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
SPECIFIC CONDUCTANCE (US/CM)
JULY 1986



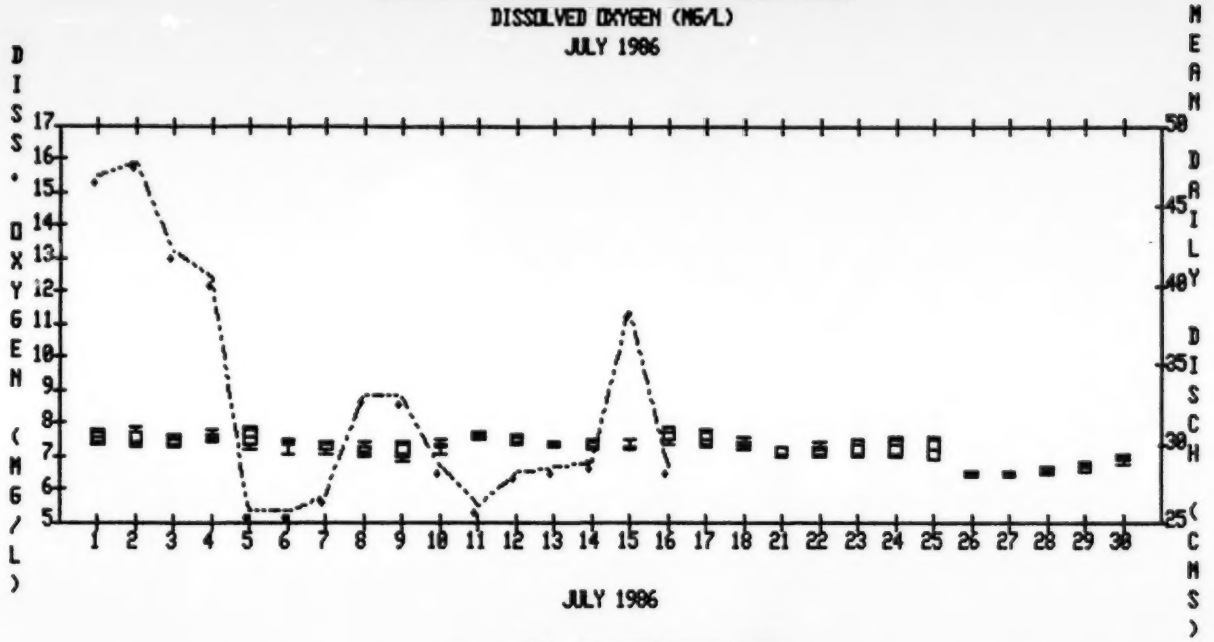
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 614 READINGS OUT OF A POSSIBLE 744

FIG. 28
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
PH (UNITS)
JULY 1986



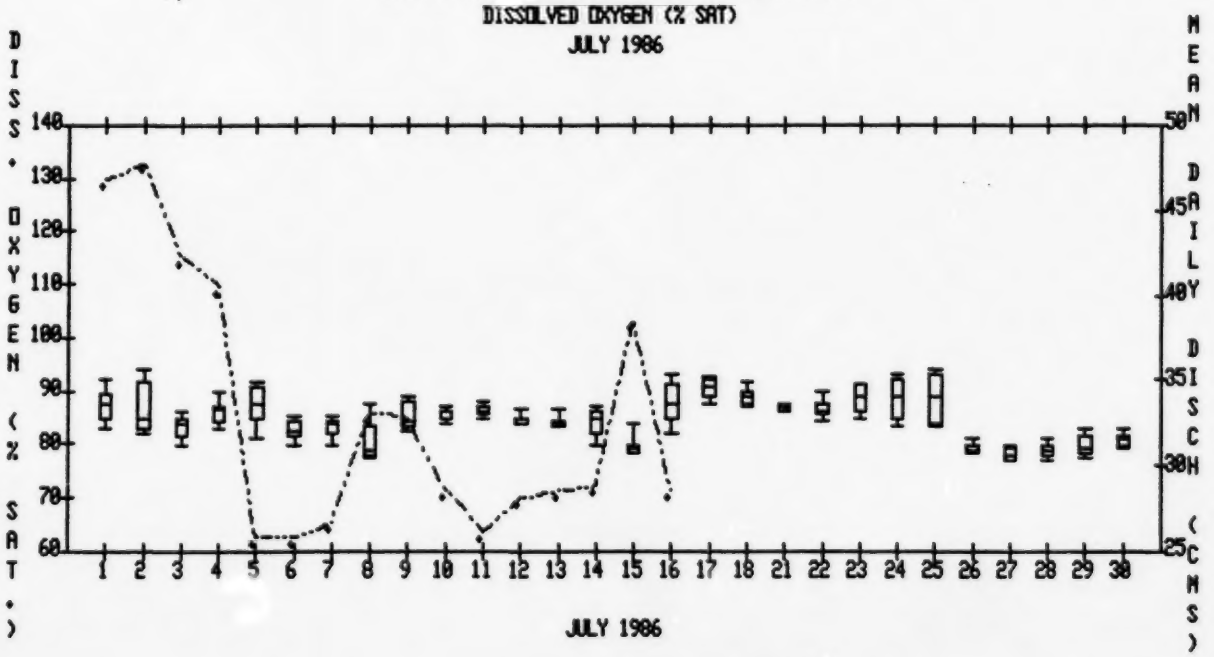
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 615 READINGS OUT OF A POSSIBLE 720

FIG. 29
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (MG/L)
JULY 1986



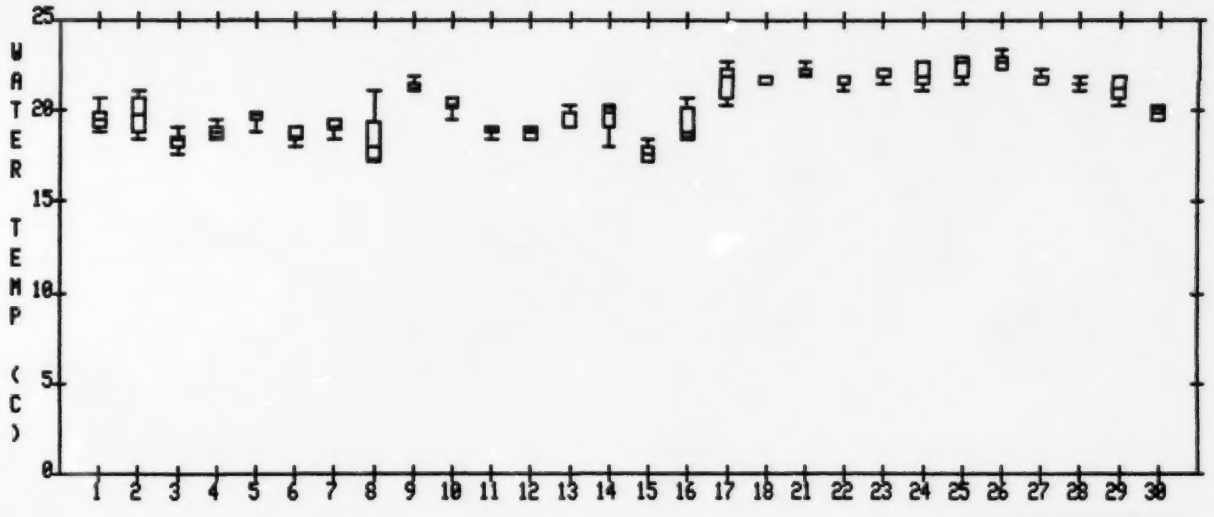
PROVISIONAL DATA ONLY
MONITOR REPORTED 615 READINGS OUT OF A POSSIBLE 744

FIG. 30
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (% SAT)
JULY 1986



NOTE:PROVISIONAL DATA ONLY

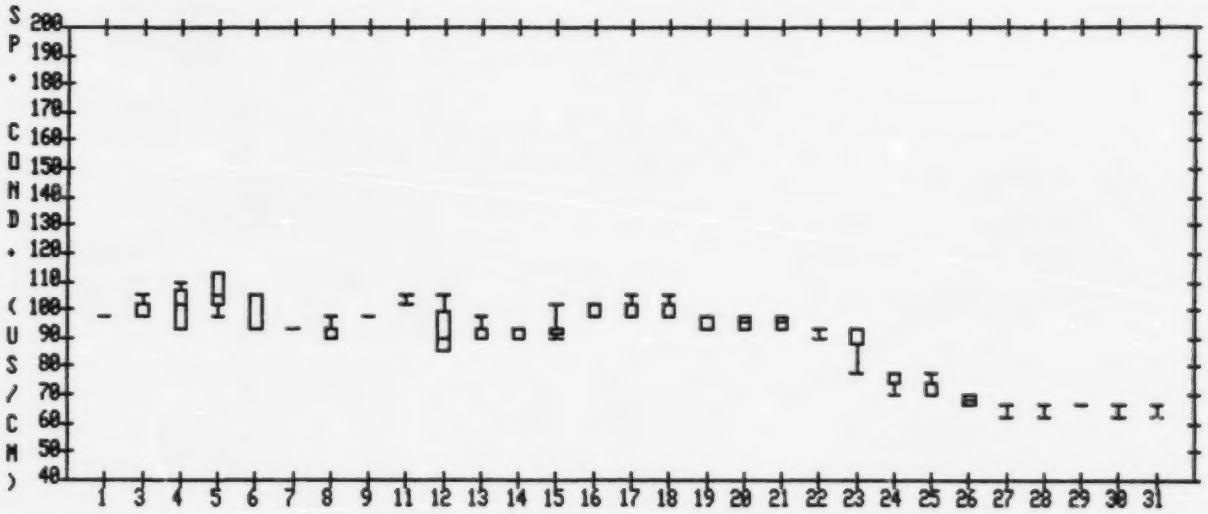
FIG. 31
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
WATER TEMPERATURE (C)
JULY 1986



JULY 1986

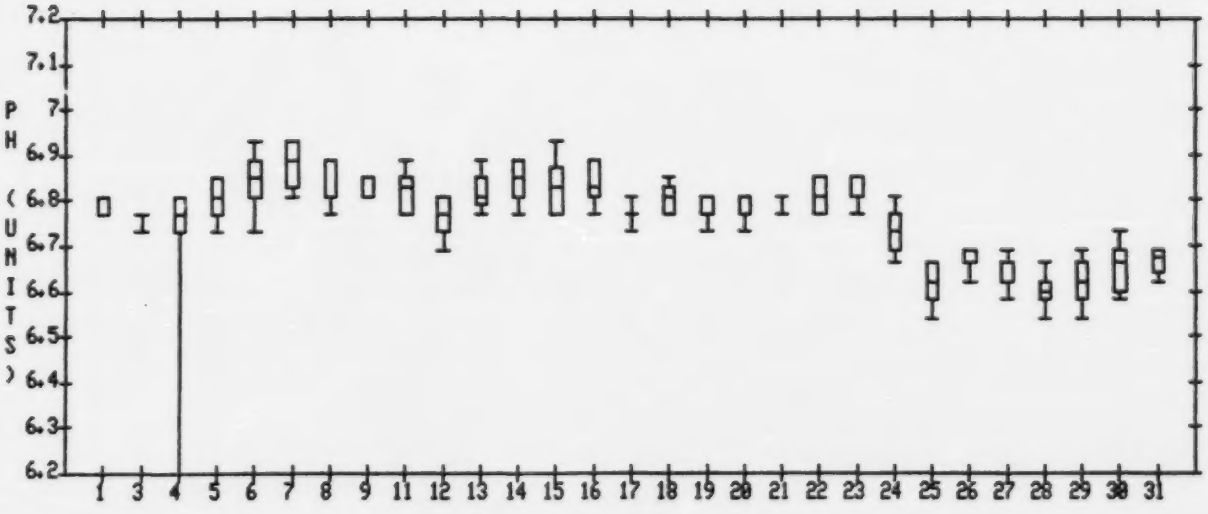
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 615 READINGS OUT OF A POSSIBLE 744

FIG. 32
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
SPECIFIC CONDUCTANCE (US/CM)
AUGUST 1986



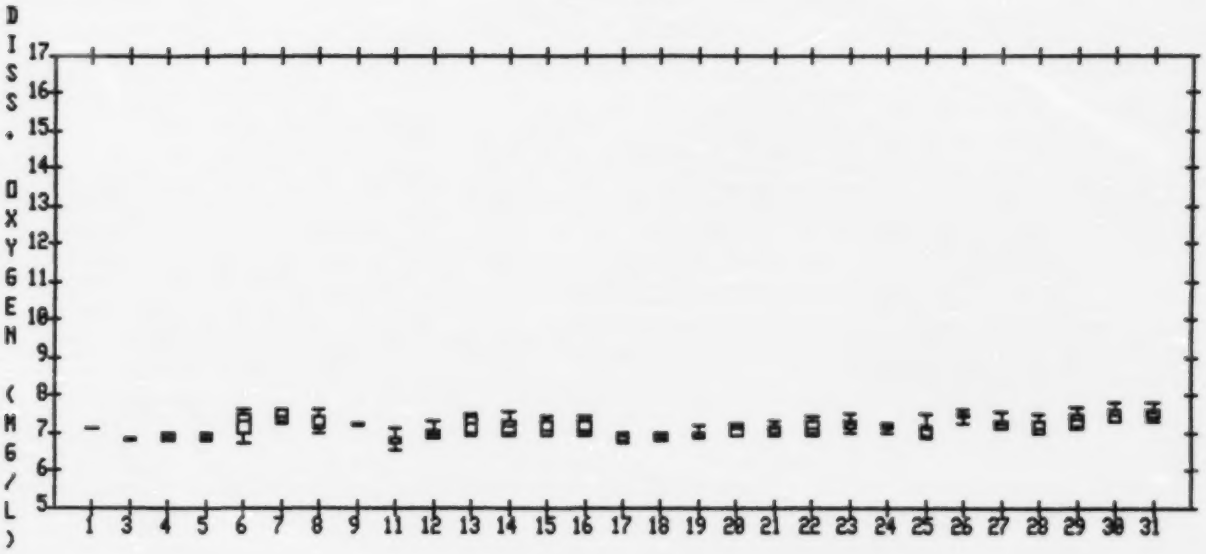
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 588 READINGS OUT OF A POSSIBLE 744

FIG. 33
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
PH (UNITS)
AUGUST 1986



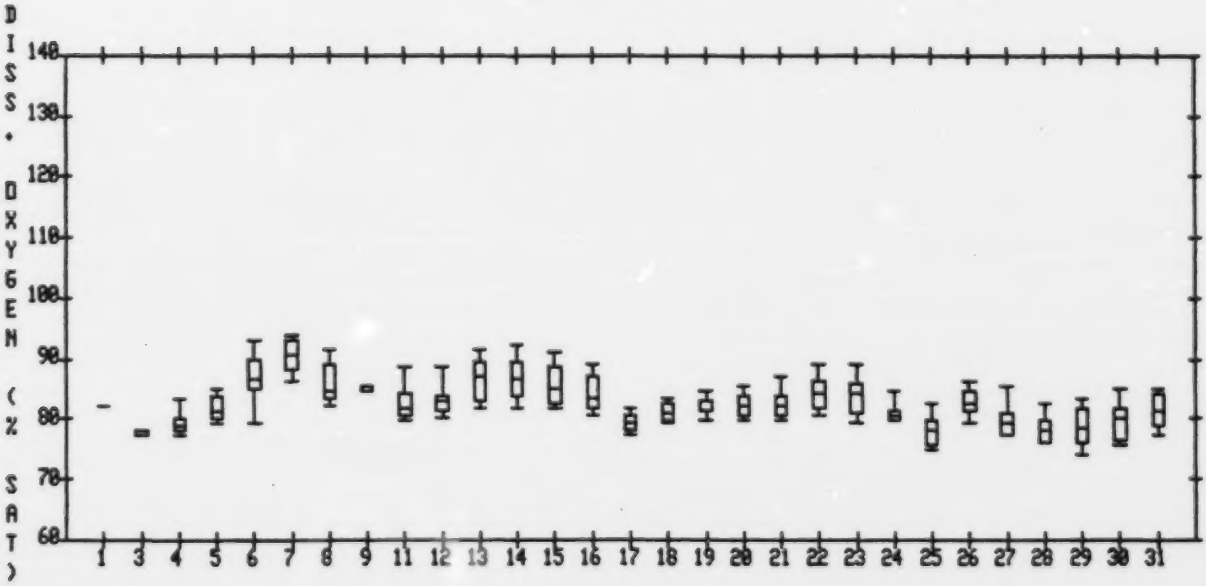
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 588 READINGS OUT OF A POSSIBLE 744

FIG. 34
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (MG/L)
AUGUST 1986



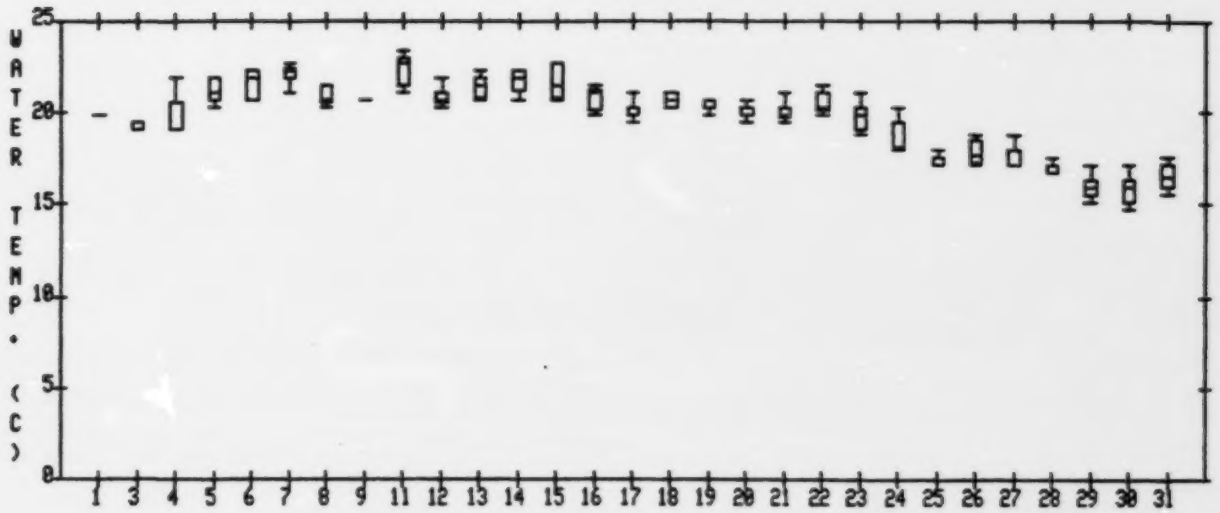
NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 588 READINGS OUT OF A POSSIBLE 744

FIG. 35
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
DISSOLVED OXYGEN (% SAT)
AUGUST 1986



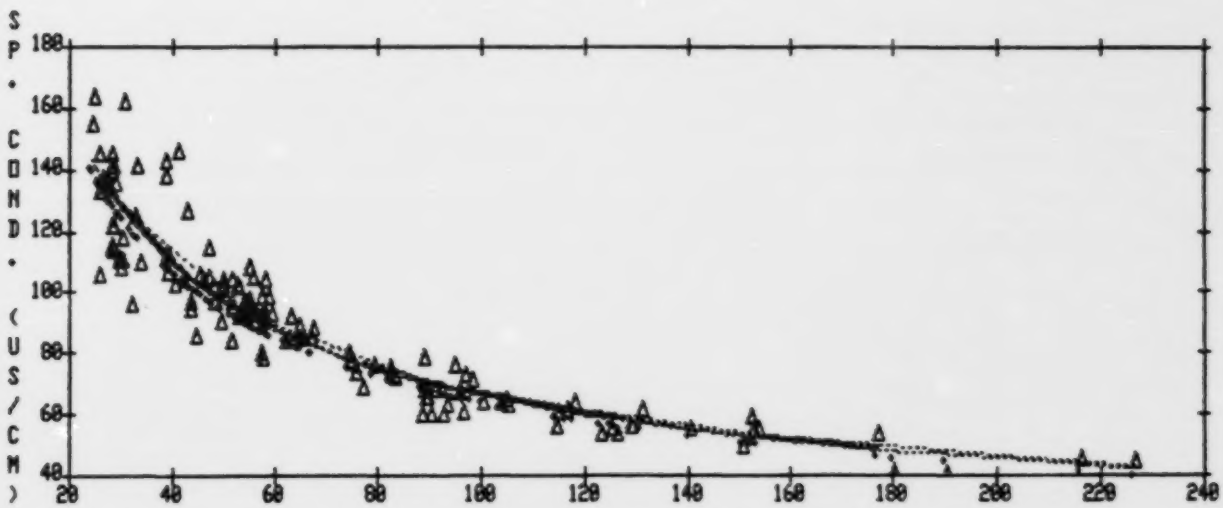
NOTE:PROVISIONAL DATA ONLY

FIG. 36
U.S.G.S. AUTO MONITOR DATA FOR ST CROIX RIVER
WATER TEMPERATURE (C)
AUGUST 1986



NOTE:PROVISIONAL DATA ONLY
MONITOR REPORTED 588 READINGS OUT OF A POSSIBLE 744

FIG. 37
DAILY MEAN SP. COND. OF ST CROIX RIVER AT MILLTOWN
VS
DAILY MEAN DISCHARGE (CMS) AT BARING
FEBRUARY 1986 - AUGUST 1986



Δ MEAN DAILY SP.COND.(AWQM MEASURED)
····· CALCD SP. COND.(K=816.04 * Q ** -0.54427)